

COVER PAGE

INSTITUTION: Indiana University–Purdue University Indianapolis (IUPUI)

CAMPUS: Indianapolis

COLLEGE: Purdue School of Science

DEPARTMENT/SCHOOL: Physics

DEGREE PROGRAM TITLE: Ph.D. in Physics

SUGGESTED CIP CODE: 40.0801

PROJECTED DATE OF IMPLEMENTATION: January 2016

NEW DEGREE PROGRAM PROPOSAL SIGNATURE PAGE

Degree Title: Ph.D. in Physics

Name of academic unit offering the new degree: Purdue School of Science, IUPUI

Include signatures from all involved programs:



Andrew Gavrin, Associate Professor and Chair
Department of Physics, IUPUI

10/1/15
Date



Simon Rhodes, Dean
Purdue School of Science, IUPUI

9/28/15
Date



Janice Blum
Associate Vice Chancellor for Graduate Education, IUPUI

10/1/15
Date

Approval Recommended by the Graduate Council

Date

M.J.T. Smith
Dean of the Graduate School

Date

Debasish (Deba) Dutta
Provost

Date

Executive Summary

A Proposal to Convert the Current Supervised Ph.D. in Physics Program at the IUPUI Purdue School of Science, Department of Physics, to a Site-Approved Ph.D. Program in Physics

The Purdue School of Science at IUPUI seeks to convert its current “supervised” Physics Ph.D. training program within the Department of Physics to a site-approved Ph.D. degree program in Physics. The Department of Physics at IUPUI has been actively involved in Ph.D. training for over 25 years under the supervision of the Department of Physics and Astronomy at Purdue University West Lafayette (PUWL). During this time, the Department of Physics at IUPUI has evolved in experience and maturity to a point where the existing arrangement has become cumbersome and unnecessary. It is now an inconvenience for both departments, rather than a necessary support. It lacks flexibility, and does not properly attribute the degrees to the Indianapolis campus where students complete all course work and research. Accordingly, the Purdue School of Science at IUPUI now seeks to convert its ongoing Ph.D. training program to a degree program that is site-approved for Indianapolis.

The supervisory arrangement has evolved from fairly tight constraint to occasional oversight. Initially, IUPUI Ph.D. students took qualifying exams written at the West Lafayette campus, and drove there to complete a portion of their course work. At present, the supervision is limited to the condition that one member of each IUPUI Ph.D. Committee has to be from the Department of Physics and Astronomy at PUWL. This constraint produces an increasing burden on faculty at both campuses. When IUPUI graduated a Ph.D. student only once every few years, it was not difficult. Recently IUPUI has typically awarded three Ph.D.’s in physics each year, and it has become increasingly difficult to find adequate numbers of PUWL faculty willing to commit to serve on the required committees.

The new degree program (culminating in a Ph.D. in physics) will reflect the intrinsic nature of the studies performed at Indianapolis, where traditional sub-disciplines in physics are complemented by an unusually strong emphasis on biophysics, in accordance with the IUPUI campus mission. Currently there are no other Ph.D. programs in physics in the greater Indianapolis metropolitan area. The proposed Ph.D. program in physics will empower the degree recipients’ with tools sought by many academic and industrial sectors at the local, state and national level. Aside from the obvious impact of the planned degree program on the local economy, the national labor market for graduates with doctoral degrees in physics is strong; employment growth for traditional fields of physics through 2022 is projected to be around 6% in Indiana. This number increases to 19% for the field of biophysics. The 2012 median pay for Ph.D. holders in physics was \$60,000 above the median annual wage for all workers.

As described in this proposal, the site-approved Ph.D. degree sought will better reflect the activities that take place at IUPUI. It will enhance the Physics Department’s ability to attract talented professors into its ranks. The course of work within the new program, both in the classroom and in laboratory-based thesis research, will remain programmatically identical to and as rigorous as it has been for over 25 years.

Since this proposal is a petition to rename and site-approve an ongoing activity, no new resources are necessary to implement it: the faculty, staff, library resources, and laboratory resources necessary to conduct this degree program are all currently in place.

Program Description

Ph.D. in Physics to be Offered by Purdue University at Indiana University – Purdue University Indianapolis (IUPUI)

1. Characteristics of the Program

- a. *Campus Offering Program*: Indiana University – Purdue University Indianapolis.
- b. *Scope of Delivery (Specific Sites or Statewide)*: IUPUI
- c. *Mode of Delivery (Classroom, Blended or Online)*: Classroom
- d. *Other Delivery Aspects (Co-ops, Internships, Clinical, Practica, etc.)*: Participation in research.
- e. *Academic Unit(s) Offering Program*: IUPUI School of Science, Purdue University Graduate School.

2. Rationale for Program

- a. *Institutional Rationale (Alignment with Institutional Mission and Strengths)*

This proposal is to establish a site-approved Ph.D. program in Physics at Indianapolis, independent from the program in the Department of Physics and Astronomy at Purdue University West Lafayette (PUWL). The Department has a successful 25-year track record in training doctoral students under the supervision of the Department of Physics and Astronomy at Purdue University West Lafayette (PUWL).

The new program will complement the vigorous research program in the Physics Department, the life sciences research emphasis of the IUPUI campus, and the existing programs in engineering and the other sciences at IUPUI. The program is closely aligned with the campus emphasis on biomedical sciences and its designation as the “Life and Health Sciences Campus” within the Indiana University System. In fact, the biophysics emphasis in the Department of Physics at IUPUI started earlier than similar efforts at PUWL and Indiana University Bloomington. Increasing the number of Ph.D. graduates is a central goal of the IUPUI strategic plan, adopted in 2013. There is also an obvious alignment with state economic development priorities related to the life and health sciences and the science, technology, engineering and math (STEM) sectors of the economy. It will also strengthen the ability of the department to compete nationally for the best faculty and students.

The site-approved program will serve several critical needs: (1) it will continue to support and enhance the research mission of the Department of Physics. Appropriate counting of Ph.D. degrees awarded for work done and courses taken at IUPUI will continue to increase the national profile of the Department. In consequence Ph.D. student and faculty recruitment will be enhanced. This will benefit the undergraduates taking physics courses and doing undergraduate research at IUPUI, as well as high school students who perform research at the Department during the Summer; and (2) producing doctoral graduates with rigorous classroom and research training in biophysics, atomic and molecular optics, quantum information, condensed matter physics, physics education and precision measurements. Approval of autonomy for the program will enhance opportunities for our graduates by raising the status of the program and by making the

program eligible for funding sources, such as the NSF IGERT program, which support growth and innovation in graduate training.

The proposed program does not represent a new training program, but rather a new, independent status for an existing training program that has operated successfully under the supervision of the Department of Physics and Astronomy at PUWL for over twenty-five years and with an increasing degree of autonomy for the last decade. Currently the program admits an average of 5 new graduate students per year and graduates 2-4 Ph.D. students per year. Independent status for the program will only minimally change most aspects of program operation and structure. Students already take all coursework at Indianapolis. All Ph.D. associated exams (qualifier, preliminary and final defense) are administered by IUPUI faculty and take place at Indianapolis. In particular, the qualifier exam has been written and graded by IUPUI faculty since 2010 by agreement with the Department of Physics and Astronomy at PUWL. Students conduct research with IUPUI faculty mentors, and are not required to visit the Purdue West Lafayette (PUWL) campus at all during their graduate careers. The only direct involvement is that one member of each Ph.D. committee needs to be from PUWL. The new program structure will follow the current structure for graduate training and the requirements of the Purdue University Graduate School, but will remove requirements for PUWL Physics approval for admissions and participation in doctoral advisory committees. This will allow the program to grow in ways that best support student success and to be tailored to the particular research strengths of the Physics faculty at IUPUI.

Developing an excellent site-approved Ph.D. program is consistent with the mission and vision statement for IUPUI:

Indiana University–Purdue University Indianapolis (IUPUI), a partnership between Indiana and Purdue universities, is Indiana’s urban research and academic health sciences campus.

IUPUI’s mission is to advance the state of Indiana and the intellectual growth of its citizens to the highest levels nationally and internationally through research and creative activity, teaching and learning, and civic engagement.

By offering a distinctive range of bachelor’s, master’s, professional, and Ph.D. degrees, IUPUI promotes the educational, cultural, and economic development of central Indiana and beyond through innovative collaborations, external partnerships, and a strong commitment to diversity.

Our vision: To be a leading urban research institution recognized for the success of its students, its advances in health and life sciences, and its intellectual, economic, and cultural contributions to the well-being of the citizens of Indianapolis, the state of Indiana, and beyond.

b. State Rationale

There is broad agreement that the future of Indiana is a high technology future, driven by excellence in the STEM disciplines: Science, Technology, Engineering, and Mathematics. Recent descriptions of this future include the Indiana Chamber of Commerce’s “*Indiana Vision 2025*” and the Indiana Commission for Higher Education’s “*Reaching Higher, Achieving More.*” In these and other publications, it is clear that Indiana’s future requires continued robust development in biomedical, energy, information technology, aerospace, defense, and other sectors in which physics plays a fundamental role. This proposal supports these efforts both directly and indirectly.

The proposed program will have (in its current state, already has) a direct, positive impact through its research and training efforts. Our Ph.D. students have worked collaboratively on projects with researchers in medicine, engineering, biology, chemistry, and other fields, as well as with personnel from industry. They have also enhanced undergraduate education in physics, chemistry, biology, and engineering, and worked with students and faculty at public and private high schools.

The Department of Physics is actively engaged in the newly instituted “LGRAD” graduate training partnership between the School of Science and Eli Lilly – through this program, eligible and academically admissible Lilly employees can receive Ph.D. training through a leave-of-absence with a guarantee of employment upon graduation.

Administratively, the correct assignment of Purdue degrees *earned at IUPUI* to the Indianapolis campus through the institution of a site-approved program addresses a direct request made by the ICHE. Attributing the Ph.D. work conducted at IUPUI to the campus as opposed to a supervising department it is not only just, it will also accurately reflect the role and ongoing activities of IUPUI in the state.

c. Evidence of Labor Market Need

i. National, State, or Regional Need.

Employment demand for doctoral graduates in physics is steady or increasing. According to O-Net Online (www.onetonline.org), demand for physicists in Indiana is projected to increase by 6% from 2012-2022 (10% nationally). In this category, 52% require a doctoral degree (23% requiring a doctoral degree alone, 29% also requiring postdoctoral training). Median salary in Indiana is \$86,000 (10th-90th percentile is \$53,400-\$187,200). The median and 10th-90th percentiles at the national level are \$109,600, \$54,900, and \$184,600 respectively.

Opportunities in the related area of Biochemistry/Biophysics are projected to increase in Indiana and nationally by 19% (same as the national projection), with a large fraction, 73%, requiring doctoral training (and of these 32% require postdoctoral training). Within this sub-field, the median salary in Indiana is \$93,600 (10th-90th percentile is \$64,900-\$143,900). The median and 10th-90th percentiles at the national level are \$84,900, \$44,200, and \$149,100 respectively.

ii. Preparation for Graduate Programs or Other Benefits.

The Ph.D. is a terminal degree, but a large fraction of graduates will go on to post-doctoral training in physics and related fields. Some graduates will use their training in other careers such as law and business and will seek advanced degrees in these areas.

iii. Summary of Indiana DWD and/or U.S. Department of Labor Data

Indiana Department of Workforce Development data do not specifically address demand for doctoral graduates, but overall demand in the sciences in the state is strong. For example, DWD predicts growth in employment for physical scientists 287 positions or 16.6% from 2010 to 2020 (above the 13.9% combined for the whole labor force, and 14.3% within the Life, Physical and Social Science Occupations category). More fundamentally, efforts to make Indiana a top-five

state for entrepreneurship will be hindered until the pool of individuals trained to the doctoral level in physical sciences is significantly enhanced.

iv. National, State or Regional Studies

Data from the NSF Survey of Doctoral Recipients¹ shows that of 44,000 doctoral graduates in Physics, only 1100 (2.5%) were unemployed at the time of the most recent survey (2013). This is in the context of a significant increase in the number of Ph.D.s granted in these fields. Employment of doctoral graduates in Indiana was approximately 1600 in this sector in 2013 (SDR). Thus, the job market for graduates from this program remains robust.

v. Surveys of Employers or Students and Analyses of Job Postings

The track record of graduates with a Ph.D. in Physics from IUPUI in advancing their careers is clear evidence of demand for the skills. Graduation and employment data are shown in Appendix C. Job postings requiring a Ph.D. in physics are routinely published online by the American Institute for Physics, in *Physics Today* (an American Physics Society journal), and in major publications such as *Science* and *Nature*.

vi. Letters of Support

See Appendix A.

3. Costs of and Support for the Program

a. Costs

i. Faculty and Staff

No new faculty lines or staff members are needed to meet the needs of a site-approved Ph.D. program in Physics. The Department of Physics at IUPUI has 13 tenure track faculty (4 assistant professors, 4 associate professors and 5 full professors) with regular appointments in the Purdue University Graduate School and who are currently able to serve on graduate committees and to mentor students. The department also has three full-time lecturers and one associate scientist.

ii. Facilities

The program will be supported by teaching and research facilities that currently exist on the IUPUI campus, and are used in the current program.

iii. Other Capital Costs (e.g. Equipment)

No new equipment or other capital costs are needed to site-approve this program. Student research will be supported by existing capital equipment in the School of Science or by equipment purchased with funds secured by external research awards.

¹ (SDR; <http://www.nsf.gov/statistics/srvydoctoratework>)

Table 1
 Question 3a: Cost of and Support for the Program
 Detail on Direct Program Costs
 Indiana University-Purdue University Indianapolis
 Doctor of Philosophy in Physics

	Year 1		Year 2		Year 3		Year 4		Year 5	
	<u>FTE</u>	<u>2016-17</u>	<u>FTE</u>	<u>2017-18</u>	<u>FTE</u>	<u>2018-19</u>	<u>FTE</u>	<u>2019-20</u>	<u>FTE</u>	<u>2020-21</u>
Personnel Services										
Faculty	0.4	\$ 36,000	0.7	\$ 63,000	1.1	\$ 99,000	1.5	\$ 135,000	1.8	\$ 162,000
Staff	-	-	-	-	-	-	-	-	-	-
Graduate Assistants	0.5	23,000	1.0	46,000	1.5	69,000	2.0	92,000	2.5	115,000
Total Personnel Services		\$ 59,000		\$ 109,000		\$ 168,000		\$ 227,000		\$ 277,000
Supplies and Expense										
General Supplies and Expense		\$ 21,600		\$ 43,200		\$ 64,800		\$ 86,400		\$ 100,800
Recruiting		-		-		-		-		-
Travel		-		-		-		-		-
Library		-		-		-		-		-
Total Supplies and Expense		\$ 21,600		\$ 43,200		\$ 64,800		\$ 86,400		\$ 100,800
Equipment										
New Equipment (see narrative)		\$ -		\$ -		\$ -		\$ -		\$ -
Equipment Replacement		-		-		-		-		-
Total Equipment		\$ -		\$ -		\$ -		\$ -		\$ -
Facilities (see narrative)		\$ -		\$ -		\$ -		\$ -		\$ -
Student Assistance										
Graduate Fee Scholarships		\$ -		\$ 12,100		\$ 48,500		\$ 84,800		\$ 121,100
Fellowships		-		-		-		-		-
Total Student Assistance		\$ -		\$ 12,100		\$ 48,500		\$ 84,800		\$ 121,100
Total Costs		\$ 80,600		\$ 164,300		\$ 281,300		\$ 398,200		\$ 498,900

b. Support

i. Nature of Support (New, Existing, or Reallocated)

Since this is a continuation of an ongoing program, only existing funding will be used.

ii. Special Fees above Baseline Tuition

The site-approved Ph.D. in Physics program will have the same tuition and fees as other School of Science graduate programs.

4. Similar and Related Programs

a. List of Programs and Degrees Conferred

i. Similar Programs at Other Institutions

There are three Ph.D. programs in Indiana with the largest being at Indiana University Bloomington (IUB) and Purdue University West Lafayette (PUWL), the program through which we are now operating. There is also Ph.D. program at the University of Notre Dame.

PUWL organizes its research into the following areas:

- (1) Accelerator Mass Spectrometry
- (2) Applied Physics
- (3) Astrophysics & Relativity
- (4) Atomic, Molecular, and Optical (AMO) Physics
- (5) Biological Physics
- (6) Condensed Matter Physics
- (7) Nuclear Physics
- (8) High Energy Particle Physics
- (9) Physics Education
- (10) Planetary Physics and Geophysics

IUB lists its research clusters in the following way:

- (1) Accelerator Physics
- (2) Astrophysics
- (3) Biophysics, Biomaterial Sciences, and Biocomplexity
- (4) Condensed Matter Physics / Materials Research Physics
- (5) Elementary Particle / High Energy Physics
- (6) Gravitational Physics
- (7) Mathematical Physics
- (8) Neutrino Physics
- (9) Nuclear Physics

The **University of Notre Dame** advertises a range of research opportunities as follows:

- (1) Astrophysics

- (2) Atomic Physics
- (3) Condensed Matter Physics and Biophysics
- (4) Elementary Particle Physics
- (5) Nuclear Physics

ii. Related Programs at the Proposing Institution

The only similar program at the proposing institution is the current “supervised” Ph.D. program in Physics, which this program will replace.

b. List of Similar Programs Outside Indiana

There are too many Ph.D. in physics programs to list in this proposal—essentially, there are programs at every research university, since a doctoral program is an important complement to a high level of research activity. The most recent National Research Council ranking of research doctoral programs (<http://sites.nationalacademies.org/PGA/Resdoc/index.htm>) lists 161 programs under the category of Physics. Each program is unique and distinguished by the particular research interests of the participating faculty. This includes programs at all the research institutions in the MHEC States.

c. Articulation of Associate/Baccalaureate Programs

Not applicable.

d. Collaboration with Similar or Related Programs on Other Campuses

Faculty in the Department of Physics have extensive collaborations with researchers in Physics/Physics and Astronomy departments at IU, Purdue, and other campuses in Indiana. Faculty also collaborate with researchers in engineering at IUPUI and PUWL, in the IU School of Medicine, and with researchers in chemistry, biology and other disciplines. These collaborations are primarily focused in the sub-fields in which IUPUI physics faculty are most active, including, biophysics, condensed matter physics, optics, atomic physics, studies of fundamental forces, and physics education research. Biophysics is a particular strength at IUPUI, which established a research effort in this area before similar efforts began at PUWL or IU Bloomington.

5. Quality and Other Aspects of the Program

a. Credit Hours Required/Time to Completion

The minimum number of credits required to complete the Ph.D. degree is 90 hours. For students directly admitted to the Ph.D. program the coursework number of credit hours ranges from a minimum of 24 up to 42 hours of coursework (most students take 30 credit hours of coursework). The rest of the hours are completed by research credits (PHYS 699) under the supervision of the student’s mentor. Typically, graduate students enroll in 9 credit hours of combined coursework and research during the Spring and Fall semesters. The credit hour requirements for the Ph.D. can be completed in 5 years; accomplishing the research goals, however, often takes longer in Physics, with 6 years being typical. Students with a MS degree from an US institution transfer 30

credit hours. Up to 9 credits can be transferred from graduate non-degree hours. Sample plans of study are included as Appendix A.

b. Exceeding the Standard Expectations of Credit Hours

Not applicable.

c. Program Competencies or Learning Outcomes

Upon completion of the Ph.D. in Physics, students should be able to carry on all the activities necessary to perform independent original research. Towards this end, students would be able to:

- Demonstrate an increased understanding in all sub-disciplines in physics;
- Integrate concepts and ideas from different sub-disciplines in physics to address novel physics phenomena;
- Design and conduct well conceived, significant research projects in a sub-discipline of physics;
- Critically analyze and evaluate data collected by themselves or others in the field and make judgments about the quality and significance of the data;
- Effectively communicate the results of research in written form to qualified individuals in the field in publications in the scientific literature;
- Orally communicate research results to a professional audience and engage in dialogue with other researchers in the field;
- Demonstrate in-depth knowledge of the scientific literature in the chosen field of inquiry and use this knowledge effectively to inform the selection of research questions and the approach to be taken;
- Conceive new ideas or new ways of understanding physics questions;
- Demonstrate an appreciation of ethical concerns in research and the importance of research integrity;
- Demonstrate mastery in the sub-discipline of choice.

d. Assessment

Assessment of progress towards achieving the competencies expected of Ph.D. graduates will be assessed at multiple stages during the student's career:

- Students must pass a qualifier examination. This examination covers the fields of Classical Mechanics, Thermodynamics, Electricity and Magnetism, Modern Physics and Quantum Mechanics at the undergraduate level. Students may take the qualifier examination the week before starting their studies at IUPUI. They must take it after the completion of the first semester of studies. If they do not pass the examination at this time, they have a last option before the start of their third semester at IUPUI. The qualifier examination consists of a two-part written exam of eight questions each spread over two consecutive days. Each part has a time limit of three hours.
- Coursework is assessed through examinations, oral presentations and written reports. All are focused on high-level activities such as application of theory to physical problems, analysis of complex physical situations, and synthesis of experimental and theoretical results. Stu-

dents need to maintain a 2.8 GPA and cannot get a grade below B- in any 50000 or 60000 level physics course.

- In a preliminary exam, which should be taken at the end of the second year, students present and defend a written proposal of the work planned for inclusion in the doctoral dissertation. The student's advisory committee of five or more graduate faculty, including the research mentor, oversees the preliminary exam. The committee is to be composed of at least one experimentalist, at least one theoretical physicist, and at least one member from a sub-discipline other than that of the dissertation work.
- Students meet at least annually with their advisory committee to review progress towards completion of the research that will be included in the dissertation.
- Students submit the final dissertation to the advisory committee for approval at least two weeks before the scheduled dissertation time. They are examined at an oral defense of their research by the advisory committee and the graduate faculty.

e. Licensure and Certification

Not applicable.

f. Placement of Graduates

Placement of graduates is detailed in the list of previous Department of Physics at IUPUI Ph.D. students, as shown in Appendix C. Students have gone on to postdoctoral fellowships at prestigious national research institutions, including Stanford, University of Texas at Austin, and the University of Notre Dame. A number of graduates have progressed to faculty positions at Universities in Indiana (IPFW, Marion College) and elsewhere in the United States. Many students hold positions in industry in the telecommunications and manufacturing areas, or have been employed by the federal government.

g. Accreditation

Accreditation is not available for Ph.D. programs in Physics.

6. Projected Headcount and FTE Enrollment and Degrees Conferred

Institution/Location: Indiana University-Purdue University Indianapolis Program:
 Doctor of Philosophy in Physics
 Proposed CIP Code: 40.0801
 Base Budget Year: 2015-16

Table 2

	Year 1 2016-17	Year 2 2017-18	Year 3 2018-19	Year 4 2019-20	Year 5 2020-21
Enrollment Projections (Headcount)					
Full-time	5	10	15	20	25
Part-time	-	-	-	-	-
	5	10	15	20	25
Enrollment Projections (FTE)					
Full-time	4	8	11	15	19
Part-time	-	-	-	-	-
	4	8	11	15	19
Degree Completion Projection	-	-	-	-	5

CHE Code:
 Campus Code:
 County Code:
 Degree Level:
 CIP Code:

Data on Ph.D. Graduates:

Last name	First name	Year*	Last known employer
Landy	Steve	1991	Warren Central HS
Lu	Xiaoyuan	1994	Hong Kong University
Du	Jinying	1996	Abbott Labs
Zhu	Lingyang	1996	University of Illinois, Urbana-Champaign
Fang	Yuncaï	1997	Proctor and Gamble
Brzustowicz	Michael	1998	University of San Francisco
Lin	Yan	1999	Dun & Bradstreet
McCabe	Melvin	2000	Ateneo de Manila University, Phillipines
Wu	Qiong	2003	Univ. of Texas Southwestern Medical Ctr.
Lu	Yajun	2004	Photonics International
Carter	Michael	2004	US Patent and Trademark Office
Shafiei	Farbod	2009	University of Texas, Austin
Ayieta	Elijah	2010	University of Nairobi
Soni	Smita	2010	IU South Bend
Jamell	Christopher	2011	Naval Criminal Investigative Service
Johnson	Merrell	2011	Indiana Univ. Purdue Univ. Fort Wayne
Lawrence	Tom	2012	IUPUI - Columbus
Srinivasan	Prashant	2013	California Polytechnic San Luis Obispo
Wassall	Cynthia	2013	Full time Parent
Carvell	Jeffrey	2013	Marion University
Williams	Justin	2014	IUPUI
Scott	Derek	2014	US Navy
Thompson	Clint	2014	Naval Research Lab
Ding	Yu	2015	University of Texas, El Paso
Khatiwada	Rakshya	2015	University of Wisconsin, Madison

*Academic year during which the Ph.D. was awarded

Appendix A

1. Curriculum and Requirements

a. Admissions Requirements

Applicants must have a Bachelors or equivalent degree from an accredited college or university. The decision to admit is based primarily on the quality of the undergraduate work, including the quality of the institution, selection of a challenging program of study, grades, and evidence of undergraduate research.

Students should have a strong background in the following areas of physics and mathematics including

- Classical Mechanics including Lagrangian methods
- Classical Electrodynamics including special function and multipole expansions
- Quantum Physics including operator methods
- Thermal/Statistical physics
- Laboratory methods beyond the introductory level
- Calculus including vector calculus
- Differential equations
- Linear algebra

Applicants from related fields in pure and applied sciences, and engineering, may be accepted on a probationary basis until they have completed any necessary undergraduate courses.

Applicants must submit the following documentation:

- Official transcripts from all undergraduate and graduate institutions they have previously attended
- Graduate Record Exam (GRE) scores for the general exam. The physics exam is not required, but is strongly encouraged.
- Three letters of recommendations from professionals familiar with the applicant's academic or professional background.
- Foreign students must take the TOEFL or IELTS. The minimum scores required for admission are 79 (TOEFL internet-based test); 213 (TOEFL computer-based test); or 6.5 (IELTS).

b. Curriculum Requirements

Completion of the doctoral program requires several major steps.

- Pass the qualifying exams
- Establish a Ph.D. Committee
- Establish a Plan of Study
- Pass the Preliminary Exam
- Complete annual progress reports
- Complete 90 credit hours of course work

- Perform substantial independent research, culminating in a written dissertation
- Successfully defend the dissertation

Qualifying exams given twice a year, shortly before classes begin in the Fall and the Spring semesters. The Qualifying Exam must be taken, at the latest, after completing the first semester of graduate work. Students are allowed two attempts to pass the exam, plus an optional attempt before starting our program at IUPUI. The examination consists of two, 3-hour parts given on successive days. There are eight problems in each part. All problems focus on topics typically covered in the undergraduate physics curriculum.

The Ph.D. committee will consist of a minimum of five members. The major professor (student's advisor) is Chairman of this committee. The student selects a second member of the committee. Two additional members should be chosen by the student, but must be approved by the Graduate Committee. These four members must be chosen to meet the following requirements: (i) one experimentalist, (ii) one theorist, and (iii) one person outside the student's research area. One committee member must be from the Physics Department at West Lafayette. The student will meet with the Committee at least twice annually to discuss research progress.

The Plan of Study for the Ph.D. degree should be filed as soon as feasible. The Plan of Study consists of a list of courses taken or to be taken by the student. The advisor and the student's Committee must approve the Plan of Study. It must be filed prior to scheduling the Preliminary Examination. Minor changes in the Plan of Study may be made to the Plan of Study by submitting the form "Request for Change to the Plan of Study." Major changes in the Plan of Study require resubmission of the Plan of Study.

The Preliminary Examination should be scheduled within one year of the completion of the M.S. degree. The exam involves several steps:

1. The Ph.D. advisor, with the assistance of the student's Ph.D. Committee, will advise the student on the content of the examination. Generally, it is expected that the content will address aspects of the student's proposed Ph.D. research.
2. The student prepares a 10-25-page report on his/her proposed research and results obtained to date. The student will be expected to understand the significance of the research and be able to place it in a broad perspective.
3. The Ph.D. Committee will review the written report and schedule an oral examination to test the student's preparedness to pursue Ph.D. studies.
4. Questions in the exam need not be restricted to specifics of the research area.
5. Based on the student's course work, his/her research proposal, and the oral examination, the Committee will determine what further course and other work may be required to properly prepare the student for his/her research, thesis preparation, and thesis defense.

Course work must total 90 credit hours or more. 60 credit hours are required for students who already have an M. S. degree from another institution in the United States. If the student transfers from another institution, up to 12 hours of approved graduate course work may be transferred. Course work must include four core courses:

1. Physics 61700, Statistical Mechanics
2. Physics 63000, Advanced Theory of Electricity and Magnetism

3. Physics 66000, Quantum Mechanics I
4. Physics 66100, Quantum Mechanics II.

The student must take three additional specialty courses approved by the Graduate Committee. These in general would be relevant to the student's area of interest. Additional courses may be taken based on the student's background and needs. The student also must register for Physics 68500, Physics Seminar, for one semester. The core courses must be completed with a minimum grade-point average of 3.00/4.00 (B average) for those courses taken here. The overall plan of study cannot contain any 500-level course with a grade less than B- and no 60000-level course with a grade less than C-. The grade requirements for courses taken in disciplines other than physics are the same.

Research must be carried out in such a way as to meet the standards set by the major professor and other members of the Ph.D. Committee. The research student is required to keep his or her Committee informed of progress in the research program and to meet with the committee at least twice a year for this purpose as noted above. The work must culminate in a dissertation written by the student.

The dissertation is subject to approval by the major professor and the student's advisory committee. The dissertation format is subject to the regulations of the graduate school.

The defense begins with a 30-minute presentation by the Ph.D. candidate, summarizing the research goals, methods, and findings. The presentation, and a subsequent question and answer period are open to the public. Once questions from the general audience have been addressed, a private session commences in which the candidate addresses additional questions from the Ph.D. committee. At the conclusion of these questions, the candidate is excused while the committee deliberates and votes on the acceptability of the dissertation.

Sample Curriculum for physics graduate students is summarized below. This program assumes a student who has previously earned a Bachelor's, but not a Master's degree, as is the norm in physics departments nationwide. Course numbers are defined in the course list that follows.

Year	Semester	Course	Credit hours
1	Fall	PHYS 51000 - Physical Mechanics PHYS 60000 - Methods of Theoretical Physics PHYS specialty course 1	9
1	Spring	PHYS 53000 - Electricity and Magnetism PHYS 66000 - Quantum Mechanics I MATH elective	9
1	Summer	PHYS 59000 - Reading and Research	3
2	Fall	PHYS 61700 - Statistical Mechanics PHYS 66100 - Quantum Mechanics II PHYS 59000 - Reading and Research	9
2	Spring	PHYS 63000 - Advanced Theory of Electricity and Magnetism PHYS 69900 - Research Ph.D. Thesis PHYS specialty course 2	8
3	Fall	PHYS 69900 - Research Ph.D. Thesis	8

3	Spring	PHYS 69900 - Research Ph.D. Thesis PHYS specialty course 3	8
4	Fall	PHYS 69900 - Research Ph.D. Thesis PHYS 68500 - Research M.S. Thesis	8
4	Spring	PHYS 69900 - Research Ph.D. Thesis	8
5	Fall	PHYS 69900 - Research Ph.D. Thesis	8
5	Spring	PHYS 69900 - Research Ph.D. Thesis	8
6	Fall	PHYS 69900 - Research Ph.D. Thesis CAND991*	4

*CAND991 is a required course students need to take on the semester of their dissertation.

Existing Courses in the proposed curriculum are as follows:

Course Number	Course Title	Credit Hours
PHYS 51000	Physical Mechanics	3
PHYS 51700	Statistical Physics	3
PHYS 52000	Mathematical Physics	3
PHYS 52200	Coherent Optics and Quantum Electronics	3
PHYS 53000	Electricity and Magnetism	3
PHYS 53300	Principles of Magnetic Resonance	3
PHYS 54500	Solid-State Physics	3
PHYS 55000	Introduction to Quantum Mechanics	3
PHYS 57000	Selected Topics in Physics	3
PHYS 58500	Intro to Molecular Biophysics	3
PHYS 59000	Reading and Research	1-3
PHYS 60000	Methods of Theoretical Physics	3
PHYS 60100	Methods of Theoretical Physics II	3
PHYS 61000	Advanced Theoretical Mechanics	3
PHYS 61700	Statistical Mechanics	3
PHYS 63000	Advanced Theory of Electricity and Magnetism	3
PHYS 63100	Advanced Theory of Electricity and Magnetism II	3
PHYS 63300	Advanced Topics in Magnetic Resonance	3
PHYS 66000	Quantum Mechanics I	3
PHYS 66100	Quantum Mechanics II	3
PHYS 67000	Selected Topics in Physics	1-3
PHYS 68500	Physics Seminar	0-1
PHYS 69800	Research M.S. Thesis	Arranged
PHYS 69900	Research Ph.D. Thesis	Arranged

Courses to be added. No additional courses are required for the program, and none are currently planned.

Appendix B

Program Faculty and Administrators

Ruihua Cheng, Ph.D. Experimental studies of nanoscale magnetic materials, applications in spintronic devices and sensors.

Ricardo Decca, Ph.D. Experimental studies: Near-field Scanning Optical Microscopy (NSOM) to investigate the properties of condensed matter systems at the nanoscale. Studies of the Casimir Effect. Search for new forces at the submicron range.

Andy Gavrin, Ph.D. (Chair). Physics Education research, particular focus on use of technology to support communication among faculty and students in large enrollment courses.

Yogesh Joglekar, Ph.D. Theoretical studies of graphene, memristors, and systems exhibiting PT symmetry.

Marvin Kemple, Ph.D. Development of magnetic resonance techniques for probing the dynamics and the conformation of macromolecules in liquid solutions.

Tony Lee, Ph.D. Theoretical studies at the interface of condensed matter, atomic physics, and quantum optics. Quantum and classical nonequilibrium physics with cold atoms and solid-state qubits.

Le Luo, Ph.D. Experimental studies in atomic, molecular, and optical physics. Many-body and Few-body Physics in Dimensional Crossover with Degenerate Fermi Gases.

Jeff Ou, Ph.D. Experimental studies of the quantum behavior of light. Emphasis on multi-photon interference effects and quantum entanglement.

Horia Petrache, Ph.D. Experimental studies of molecular structures and forces by physical methods including X-ray scattering, Nuclear Magnetic Resonance, and osmotic stress.

Steve Pressé, Ph.D. Theoretical and experimental studies of biological systems from the level of single molecule to systems biology. Single molecule mechanics of protein translocation, bacterial predator-prey dynamics.

Bruce Ray, Ph.D. Experimental studies of interactions that occur within an enzyme and between an enzyme and its bound substrate. Magnetic Resonance techniques.

Ed Rhoads, Ph.D. Lecturer: Astronomy, physics.

John Ross, Ph.D. Lecturer: Physics.

Gautam Vemuri, Ph.D. Experimental studies of laser physics and nonlinear optics. Statistical and nonlinear dynamical properties of lasers, quantum effects in evanescently coupled waveguide arrays.

Steve Wassall, Ph.D. Experimental studies of molecular organization within biological membranes using solid state nuclear magnetic resonance methods. Polyunsaturated membranes, peptide conformation.

Brian Woodahl, Ph.D. Senior lecturer: Physics and astronomy.

Fangqiang Zhu, Ph.D. Computational and theoretical studies of biophysics. Physics of membrane proteins such as channels and transporters, algorithm design.

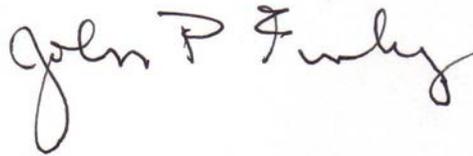
JOHN P. FINLEY
HEAD

Andrew D. Gavrin
Chair & Associate Professor
Department of Physics, LD154
402 N. Blackford St.
Indianapolis, IN 46202-3217

October 1, 2015

The graduate program in the Department of Physics of IUPUI has been overseen for many years by the Department of Physics and Astronomy at Purdue on the West Lafayette campus. We have members of the West Lafayette faculty that serve on their PhD student committees and likewise members of the IUPUI faculty serve on relevant committees in West Lafayette. However over the course of several years there has been significant growth and depth in both the faculty and research directions at IUPUI. They have become a strong and independent research department and have much to be proud of in this growth. The issue of IUPUI administering its own graduate program in Physics was vetted and discussed by the graduate oversight committee and that body unanimously endorsed that the Department of Physics at IUPUI should administer its own graduate program.

Sincerely,



John P. Finley
Head, Department of Physics and Astronomy

John C. Lechleiter, Ph.D.

Chairman, President, and Chief Executive Officer

317.276.6997 | jcl@lilly.com



Eli Lilly and Company

Lilly Corporate Center
Indianapolis, Indiana 46285
U.S.A.

www.lilly.com

May 11, 2015

Simon J. Rhodes, Ph.D.
Dean, School of Science
IUPUI
402 North Blackford Street, LD 222
Indianapolis, IN 46202

Dear Dr. Rhodes,

I am pleased to offer my support for your proposals for independent Ph.D. degrees in the School of Science at IUPUI. My colleagues at Lilly and I have been pleased to witness the emergence of the School of Science as an excellent research and learning institution and key asset in our shared ambition to make Indiana a hub of discovery and innovation. IUPUI graduates of the current Ph.D. programs awarded through the West Lafayette campus hold important positions in both our research laboratories and in other areas of our company. We have benefitted from the outstanding training they received. Clearly, you are ready to operate your own Ph.D. programs.

We have been particularly pleased with the benefits to our employees who have taken advantage of the opportunity to enhance their qualifications and contributions to our discovery mission by studying for the Ph.D. through the LGRAD program that we developed together. They are well prepared to assume higher levels of responsibility in their research groups. Moreover, this training is beneficial to the company as we seek to develop our own scientists as leaders in their fields of inquiry and to retain the best and brightest.

We also realize that your undergraduate degree students (the vast majority of whom are from Indiana) enjoy opportunities to have significant engagements in research. These research experiences help develop important skills that Indiana employers seek in new hires. Enriching the research environment by solidifying the Ph.D. degree programs will further improve the education and preparation of your undergraduates.

I believe that approval of the independent status you are requesting will strengthen your programs even further by allowing them to participate in national rankings and by making them fully eligible for external funding programs that are restricted to those with independent doctoral degrees. All of us in Indiana's life sciences community, and other contributors to our economy and quality of life, will share the benefits.

Sincerely,

A handwritten signature in black ink that reads "John C. Lechleiter".