ANNUAL ASSESSMENT REPORT FOR 2009-10
Due October 1, 2010

Department/Program: Physics and Astronomy
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Student Learning Outcome (SLO)	**For each SLO, list two methodologies and the criteria for successful performance (such as a measurement, rubric or scale that indicates a baseline for competency).**				**Term Assessed (F09 or S10)**
	Methodology 1	***Criteria for Success***	***Methodology 2***	***Criteria for Success***	
1. Demonstrate a working knowledge of the basic concepts and theory of physics.	Use an exit exam to test the students' knowledge. Currently using an in house exam similar to the GRE. Written assignments, exams, and laboratory writes at all levels.	Compare scores to national norms in each sub discipline. A mean score of 580 on the exam. Grades on each assignment.	Completing the Physics Major curriculum successfully.	Graduation Job and graduate school placement.	S10 (Exit Exam) S03-S10 (Placement)
2. Make inferences and deductions of physical systems in both the classroom and research settings, through critical thinking, problem solving, mathematical and computer modeling, and laboratory experiments.	A written survey will be used starting this Spring 2011. In its inaugural stage it will be sent to all graduates from the last 10 years. This survey will be used to assess the program.	Survey of Alumni to be done S11	Assessed through written reports for both classroom and research projects. Many of these student research project reports are kept in a student portfolio.	Passing scores on assignments and course. Successful honors thesis and student author ship	S10

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	Methodology 1	***Criteria for Success***	***Methodology 2***	***Criteria for Success***	
3. Demonstrate proficiency of the core concepts of classical and modern physics.	Use an exit exam to test the students' knowledge	Compare scores to national norms in each sub discipline. At or above national level.	Informal exit interviews are given to all graduates. Periodic contact is also made with graduates during the 2 years after graduation to determine their perceptions and recommendations of the departmental program.		S10
4. Make meaningful comparisons between experiment and theory.	Evaluated in required laboratory courses and research through written reports.	Average grade of B or higher in laboratory courses Successful completion of research projects.			S09,S10
5. Assemble experimental apparatuses either in the laboratory or computationally, conduct and analyze measurements of physical phenomena, and evaluate experimental or model uncertainty.	Majors are required to take at least two upper level laboratory oriented courses. Laboratory reports are written in a journal format. In each laboratory/computational model students must assemble, analyze their data, and evaluate uncertainty.	Successful completion of two departmental laboratory courses: AS301, PH303 PH311, PH461, or PH491	Student research projects help the department evaluate the education goals and ability of the students with regards to experimentation	Participation in independent research outside of standard curriculum. Examples would be an honors thesis, Butler Summer Institute, and a research experience such as the NSF REU.	**F10**

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	Methodology 1	***Criteria for Success***	***Methodology 2***	***Criteria for Success***	
6. Communicate ideas and processes of physics, clearly and precisely, both orally and written.	Students present their findings from research, Butler Summer Institute, or senior thesis to the full department each year or in a scientific meeting venue.	Presenting at venues such as the URC and scientific meetings.	PH495 Senior Seminar is a capstone course required of all students. In senior Seminar each student gives several presentations of both their own research and a journal article. Their talks are critiqued by both faculty and students.	Completing PH495 with a passing score on both final presentation and course.	**S10**

1. **Findings—***Summarize the findings from the assessment activities for each SLO that was assessed. Identify the SLO # and append supporting documentation such as rubrics, scales, pass rates, test scores, or other measurements used to assess each SLO.*

EXIT EXAM RESULTS (APRIL 2010)

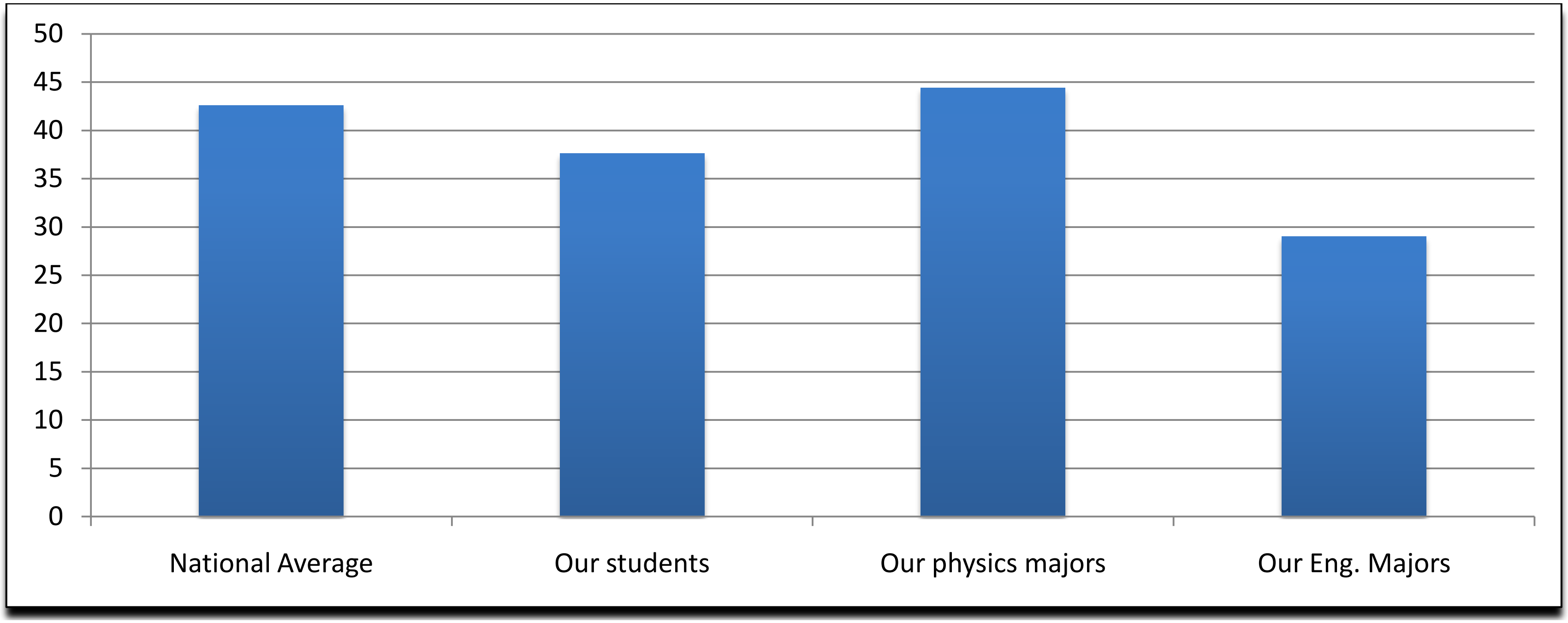

Figure 1. Exit exam results for Spring 2010. Nine students took the exit exam.

SLO 1: Demonstrate a working knowledge of the basic concepts and theory of physics.

METHOD 1: We have instituted the exit exam in the last few years. The exam is very similar to the GRE and the results of this exit exam have been compared to the national scores for the GRE Physics advanced exam. A word of warning when interpreting these results, it should be noted that those students who take the Physics GRE exam are usually those only intending to go onto graduate school in physics. These students typical represent a smaller subset of all students getting bachelor's degrees in physics both in the USA and abroad. Typically this percentage taking the exam is less than 40% of all physics seniors in the nation. If all graduating physics seniors students took the Physics GRE the national average would be markedly lower. Due to small number statistics of our department more testing will be needed to properly understand the results.

The results of the exit exam are shown in Figure 1. The average of our all our senior students was 37.6, below the national average (42.6) but very respectable since we are only comparing our students to those intending to go graduate school in physics. In general the results show that those students preparing to go on to graduate school (generally pure physics majors) have a better comprehension of the concepts and theory. They scored 44.4. But these results may be due to the fact that they have studied for the GRE exam prior to taking our exam and have taken more pure physics courses then the dual degree engineering students. One item of concern is that those students scoring under our threshold for success tend to be dual degree physics engineering students. They scored well below the national average (29). This is generally seen not only in the exit exam but all levels within the curriculum. This is likely due to these students taking fewer advanced physics courses than the pure physic majors. Also the dual degree engineering students typically enter Butler University with lower SAT score than do the pure physics majors.

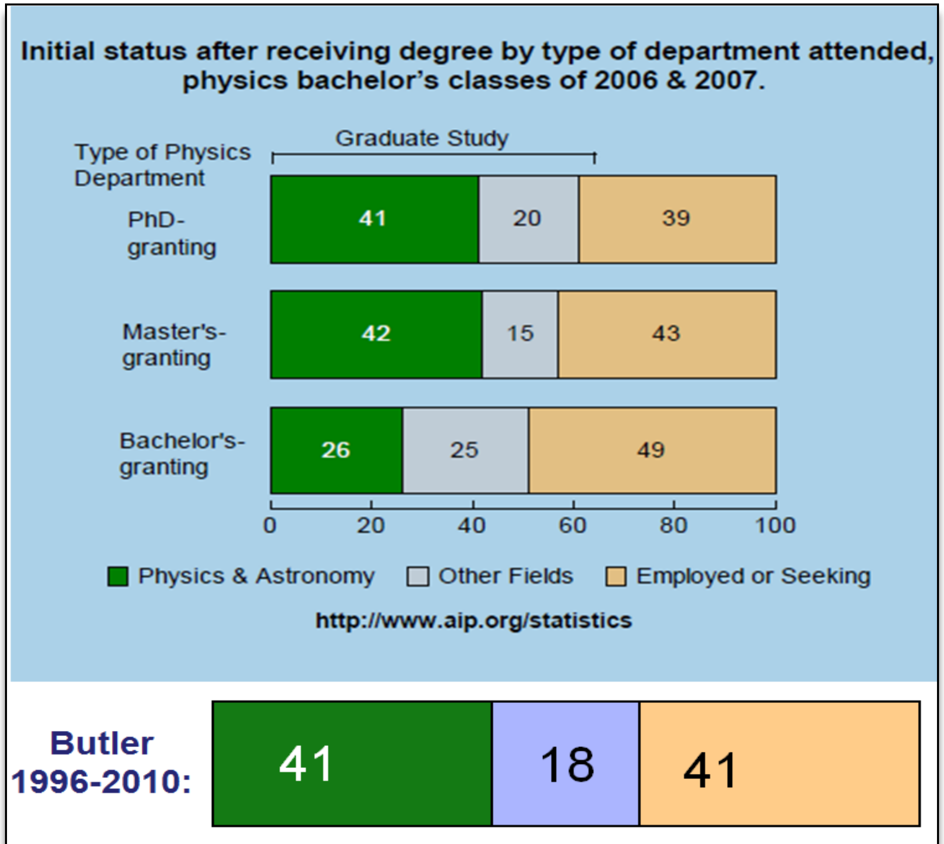

Figure 2 Placement of BU physics students.

METHOD 2: Those students who make it through the first two years of the physics major in all likelihood graduate. As mentioned in Method 1 of this SLO, we have found that dual degree engineering physics students tend to score lower on the exit exam. Though they score low they still have had a 100% placement rate into engineering jobs. One reason this difference in score between engineering/physics and pure physics majors is not a hindrance to our dual degree physics students is that they do not need the same level of working knowledge as a student continuing onto graduate school in physics.

As for placement into graduate schools, in the last year we had 100% placement into graduate school including one student going onto Cambridge University in England. Over the last decade the list has included 3 Ivy League universities.

These trends of 100% placement are the norm in our department. Figure 2 shows where our students end up. Our distribution of students going onto graduate school in physics is well above that of most bachelors granting institutes. Our department sends a comparable the same fraction of students onto physics graduate programs as research 1 institutes.

SLO 2: Make inferences and deductions of physical systems in both the classroom and research settings, through critical thinking, problem solving, mathematical and computer modeling, and laboratory experiments.

METHOD 1: We will be conducting a survey of our alumni in the Spring of 2011. So results of this survey will be addressed in the next years assessment report.

METHOD 2: As can be seen in Appendix 3 our students continue to be very active in research. All of our senior pure physics majors (e.g. non engineering students) presented, coauthored, or finished a thesis. Only a couple of our dual degree engineering students participated in research. This is mainly because their focus is on internships during the summer months versus research positions.

EXIT EXAM RESULTS FOR PHYSICS SUB DISCIPLINES

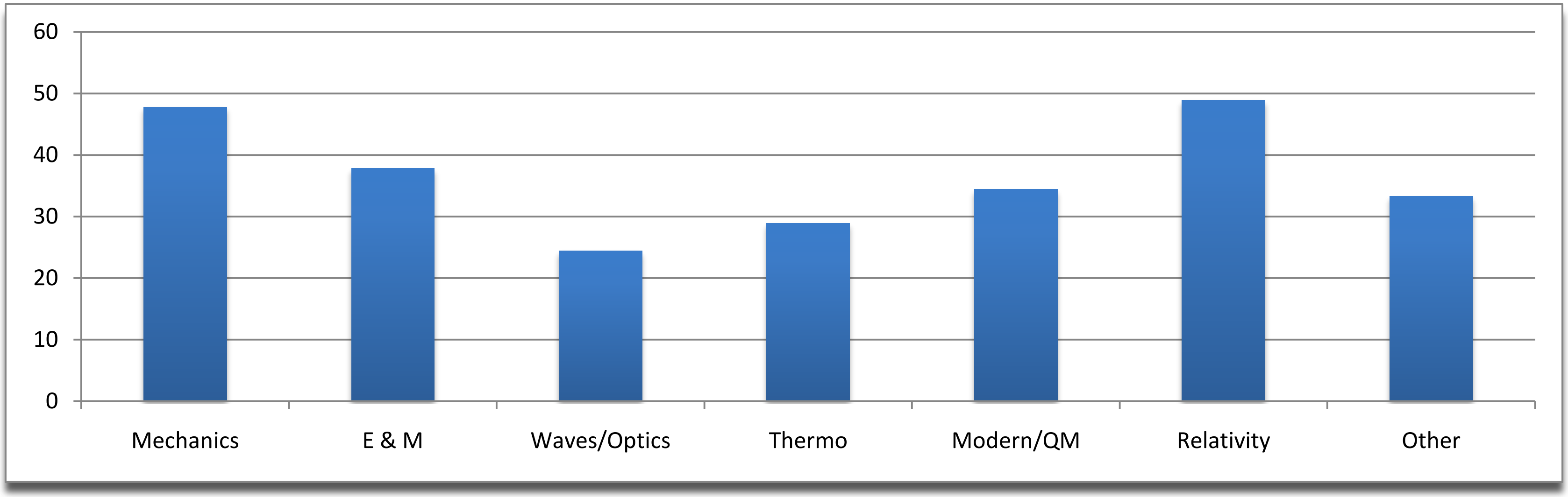

Figure 3. Exit exam scores for physics sub disciplines.

SLO 3: Demonstrate proficiency of the core concepts of classical and modern physics.

Within the exit exam we also looked at sub disciplines within physics. The lowest scoring sub discipline was waves and optics. This is partially explained by the fact we had an adjunct teach this course when these seniors were taking it. The adjunct received very poor reviews and is no longer with the department. We hope to see the scores for this subdiscipline increase in the coming year or two. The three highest scoring areas are Mechanics, Electricity and Magnetism, and Relativity. These results underscore the need to teach these courses and electives. Mechanics is a 4 cr hr course has repeated themes throughout the curriculum, E&M is a two semester 6cr hrs, and General Relativity is also two semester 6cr hrs. Those courses that are electives or where there has been minimal exposure for the students have resulted in lower scores. These results emphasize the need to not cancel or limit courses within the department, particularly those needed for the GRE.

SLO 4 & 5: Make meaningful comparisons between experiment and theory & assemble experimental apparatuses either in the laboratory or computationally, conduct and analyze measurements of physical phenomena, and evaluate experimental or model uncertainty.

METHOD 1: Of our laboratory/computational physics courses, only two are required for the major, PH303 and PH311**.** PH303 (Electromagnetic Waves and Optics) is a mainly lecture course with a lab component for students to get a first-hand experience in optics, such as observing interferences and diffractions and obtain the wavelengths of light. In PH311 (Experimental Modern Physics), students will carry out advanced experiments in physics, some of which are historically important, and others are modern experiments. For example, students will be able to study the wave-matter duality using electrons, as well as launching, tracking, and retrieving high altitude balloons using modern GPS system. In both courses students must complete a full/explanatory write up of their results in formal format. A grade of C or higher would technically be considered acceptable for graduation and success. Most of our students obtain a grade of B or higher.

Types of undergraduate research experiences taken by physics bachelor's, class of 2007.

	Percent	Butler*
As part of a thesis project or capstone experience on campus	40	35%**
Other on-campus research (e.g., participant in a faculty research project)	54	71%
REU (NSF Research Experience for Undergraduates)	23	29%
At a national lab	10	17%†
An industrial research co-op or internship	7	26%
None	26	

Note: Percentages add to more than 100% because respondents were allowed to choose more than one type of research.

http://www.aip.org/statistics

*Calculated as total number of summer projects in each category divided by total number of juniors from 2005 to 2010
** Calculated directly, 2003 to 2007 average
†Includes work at other universities or labs outside Butler

Two other popular courses in the department that a majority of the students take are AS301 (Modern Astronomical Techniques) and PH461 (Computational Physics). Though the courses do not require assembly in the standard sense, students must still use scientific equipment. I in this case a telescope and or a computer to create, obtain, and analyze results. In AS301 the student experience has been enhanced by allowing the students to make a trip to Kitt Peak, AZ to use the telescope on site. The last time the course was taught (S2009) one group project led to a publication in the *Minor Planet Bulletin*. In PH461, students successfully completed an end of the semester group project where each student contributes to a part of a large computational project.

Figure 4. Research and internship experiences compared to national norms for Butler physics majors

METHOD 2: Nearly 100% of our students participate in an original research project. During summer 2010 half the Junior class had a summer NSF REU position. As seen in Figure 4 the department is well above the national norms in all categories in obtaining extramural laboratory experiences for our students. These results are very encouraging in that most or our students participate in two or more research projects and/or internships. The students have presented their research findings/experiences in PH495 and in other venues such as the URC, BSI, and national meetings. These experiences have had a positive effect on our outcomes for SLO1, the number of students continuing onto graduate school. We suspect without these experiences our students would not have their advantage of getting into graduate school.

Appendix 1 lists the extramural research and internship experiences of the department from 2003 to 2010. For a department our size we are quite pleased with the success of the students.

SLO 6: Communicate ideas and processes of physics, clearly and precisely, both orally and written.

METHOD 1: As mentioned in SLO5 a majority of our students participate in an original research experience. All of our students who have participated in these programs have had to make at least one presentation. Typically most of these students end up giving multiple presentations at venues such as BSI, URC, and as part of the NSF REU program. In addition many of our students present their findings at national meeting such as the American Astronomical Society (AAS) meeting. As an example in the last two years 7 of our students have presented their findings at the AAS meeting (a large number for a single meeting considering we have less than total 35 majors). Though not measurable we have gotten many comments from faculty at other universities as to the quality of our students' presentations.

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METHOD 2: All students are now required to take our capstone seminar course (PH495). Thus far all students have completed the requirements successfully and made successful presentations.

One item not present in the method is the number of students in our department who work at Holcomb Observatory as tour guides. Typically these students will have made hour long presentations to the general public to nearly 5000 visitors over the course of the four years at Butler.

2. **Use of Results—**W*hat programmatic changes, if any, were made in response to the findings? Reference the SLO #.*

   As a result of physics majors not being retained in their freshman year the department will be instituting a 1 credit hour freshman seminar course. This is hoped to mainly help our dual degree engineering students. These students have had a lower retention in our department and lower grades and lower exit exam scores. We hope that this will raise the retention of these students by integrating them earlier into the department.

   We will be considering the possibility of changing our exit exam. The GRE-like exit exam has limited results for assessment purposes the department. This is mainly due to the fact that it is intended for US and foreign physics majors going on to graduate school. We will be examining possible use of the physics ETS exam so that we can compare our majors to other graduating physics majors. The ETS will give us needed information on sub disciplines with in physics. This will allows us to look for shortcomings in our curriculum.

3. What **support services or resources** for faculty would help your department assess its SLOs better?

We will be using the assistance of Institutional Research to help us conduct a survey of our physics graduates over the last 10 years this coming year.

4. What **revisions**, if any, to current SLOs did you make or are under consideration?

No changes were made to the SLOs but we did make several changes to the methods so we could better assess the SLOs and goals of our program.

5. Map each of your program's SLOs to the University Learning Outcomes. Make annual updates only if your SLOs changed. For example:

Butler University students will:

1. Explore various ways of knowing in the humanities, social and natural sciences, quantitative and analytic reasoning, and creative arts. *(Know)*
2. Articulate and apply required content knowledge within their area(s) of study. *(Know)*
3. Find, understand, analyze, synthesize, evaluate and use information, employing technology as appropriate. *(Know)*
4. Explore a variety of cultures. *(Know)*
5. Recognize the relationship between the natural world and broader societal issues. *(Know)*
6. Communicate clearly and effectively. *(Do)*
7. Demonstrate collaborative behavior with others. *(Do)*
8. Practice ways and means of physical well-being. *(Do)*
9. Acquire the skills to make informed, rational and ethical choices. *(Do)*
10. Experience diverse cultures, ethnicities, religions and sexual orientations. *(Value)*
11. Share their talents with Butler and the greater community at large. *(Value)*
12. Be exposed to the value of lifelong learning. *(Value)*

Physics and Astronomy Student Learning Outcomes:	**Butler University Learning Outcomes**											
	1	2	3	4	5	6	7	8	9	10	11	12
1. Demonstrate a working knowledge of the basic concepts and theory of physics.	X		X									
2. Make inferences and deductions of physical systems in both the classroom and research settings, through critical thinking, problem solving, mathematical and computer modeling, and laboratory experiments.	X		X	X	X				X			X
3. Demonstrate proficiency of the core concepts of classical and modern physics.		X										
4. Make meaningful comparisons between experiment and theory.	X		X									
5. Assemble experimental apparatuses, conduct and analyze measurements of physical phenomena, and evaluate experimental uncertainty.			X				X					
6. Communicate ideas and processes of physics, clearly and precisely, both orally and written.		X				X					X	

6a. List all courses in the program and map each of your SLOs to the **curriculum** in which the learning occurs, indicating the extent to which the outcome is introduced (I) or refined (R). [Make annual updates only if your SLOs or curriculum changed.]

For example:

	SLO 1	SLO 2	SLO 3	SLO 4	SLO 5	SLO 6
AS102	I	I	I	I	I	
AS301				R	R	
AS311/312	R	R	R	R		
PH201/202	I	I	I	I	I	
PH301	I	I	I	I		
PH303	R	R	R	R	R	
PH311				R	R	
PH321	R	R	R	R		
PH325	R	R	R	R		
PH331/332	R	R	R	R		
PH421/422				R	R	
PH461		R			R	
PH491				R	R	R
PH495						R

6b. **Learning/developmental opportunities for students outside the classroom**—*If any SLO was addressed outside the classroom, explain where and how the learning/developmental opportunities were provided to students in your program? (i.e., internships, field experiences, visiting lectures, collaborative projects, and other creative ideas you may have employed.)*
See Appendices 1 and 3.

Appendix 1.
Butler University, Department of Physics & Astronomy
Summer Research Positions & Internships (2003-2010)

Year	Place/ Funding	Topic
2010	Communication Systems West Salt Lake City, Utah	Mechanical design and analysis
2010	National Science Foundation Research Experiences for Undergraduates	Dynamical Systems, Symbolic Dynamics and Instrumentation
2010	National Science Foundation Research Experiences for Undergraduates SARA (ETSU)	Modeling the Variation of X-rays from Wolf-Rayet Stars
2010	U of Hawaii Institute for Astronomy National Science Foundation Research Experiences for Undergraduates	Understanding Circumstellar Regions Through Optical Pumping Polarization
2010	National Science Foundation Research Experiences for Undergraduates U of Idaho	Measuring Regolith Depth on the Lunar Surface
2010	Butler Summer Institute	Searching for Dwarf Novae in Globular Clusters
2010	Butler University	Variable Stars in Globular Cluster
2010	Butler Summer Institute	The Depletion of Red Giants via a Top-Heavy Mass Function in the Galactic Center
2010	Butler University	Optogalvanic Effect
2010	Butler University	High Altitude Balloons
2010	Butler University	Quantum Diffusion-Limited Aggregation
2010	Midwest ISO – Internship	Architecture Design Decisions: An Economic Approach
2009	Indiana University National Science Foundation Research Experiences for Undergraduates	Modeling of heat diffusion for the Photothermal heterodyne imaging of virus-like particles
2009	Butler Summer Institute	Modeling the Inverse Hexagonal Phase of Lipid Molecules
2009	Butler Summer Institute	Study of Intensity Pattern of Fresnel Diffraction through a Circular Aperture

2009	Butler University	Optical Imaging
2009	UCLA National Science Foundation Research Experiences for Undergraduates	Obtaining an unbiased measurement of the position of SgrA*-IR
2009	Butler University	Modeling the time-dependence of accretion of mass by a super massive black hole from stellar evolution
2009	Indiana University National Science Foundation Research Experiences for Undergraduates	Finding bound eigenstates of bent quantum wires by the method of particular solutions
2009	Butler Summer Institute	The Effect of Collisions and Tidal Disruptions on Giant Stars in the Galactic Center
2009	Butler Summer Institute	Photometric and Rotational Properties of Asteroids
2008	Butler Summer Institute	Electromagnetically Induced Transparency in a Rubidium Vapor Cell
2008	Butler Summer Institute	Fractal Construction by Simulation of Quantum Random Motion
2008	Butler Summer Institute	Numerical Calculation of Nonlinear Seismic Wave Propagation over a Flat Surface Layer of the Earth due to a Cylindrical Source Near the earth's Surface
2008	Butler University Research	The Optogalvanic effect
2008	Butler University Seitz Award	Electron spectroscopy and assembly of an electron Position Sensing Device test chamber
2008	Butler Summer Institute	The Growth and Evolution of the Super massive Black Hole in the Milky Way Galactic Nucleus
2007	Princeton University, Princeton, NJ General Atomics, San Diego, California National Undergraduate Fellowship	Measurement and Analysis of ECH Power Injected Into DIII-D.
2007	Butler Summer Institute	The Optogalvanic Effect of Carbon Monoxide
2007	Butler University	Development of a Lens Resolution Testing System
2007	Butler University	Searching for transmitting exo-planets.
2006	University of Minnesota, Minneapolis, MN National Science Foundation Research Experiences for Undergraduates	Calibrating CCD images of the Milky Way in prep for star counts.

2006	Butler University	Rotation of Asteroids Research
2006	Butler Summer Institute	Globular Star Cluster Research
2006	Butler Summer Institute	Geophysics Research
2006	Princeton University, Princeton, NJ General Atomics, San Diego, California National Undergraduate Fellowship	Testing new uncertainty matrix for the DIII-D Tokamak.
2005	Science, Technology, and Society in Asia, Faculty-Student Research Grant from Freeman Foundation	Nanotechnology
2005	University AIX- Marseille, France	CMRNC Laboratory Research Prepared samples of nanoparticles through chemistry and physics techniques (Conclusion that I had created and was working with Fe_2O_3 iron oxide, and CoO_2, cobalt oxide)
2005	Indiana University, Bloomington NSF Research Experiences for Undergraduates	Cataclysmic variables in Globular Star Clusters
2005	Raytheon	Helicopter Altimeter/Wireless Intercom System Ultra Wide Band Radio
2005	Science, Technology, and Society in Asia, Faculty-Student Research Grant - Freeman Foundation	Nanotechnology
2005	Cummins, Inc. Columbus, Indiana	Midrange engineering, current product support, performance and fuel systems
2005	Butler Summer Institute Butler University Research Endowment	Dynamical Evolution of Core Collapsed Globular Clusters
2005	Bucknell University NSF Research Experiences for Undergraduates	Biophysics
2005	Guidant, St. Paul, Minnesota	Reliability Engineer Intern. Developed and implemented a damage descriptor for vibration and force loading · Initiated a cross functional software process for quantifying the damage inflicted on various Guidant devices.
2005	Diversified Systems, Indianapolis, IN	To develop a system to determine the most efficient/effective process by evaluating the attributes of an assembly
2005	Butler Summer Institute Butler University Research Endowment	Optogalvanic Effect
2005	Diversified Systems, Indianapolis, IN	Examining the manufacturing process to assist in standardizing the system. Examining the labor quoting

		process and organizing it.
2004	IMMI, Westfield, Indiana 9/04 – 5/05 Internship	Investigate automobile crash test.
2004	CERN Particle Accelerator Geneva, Switzerland NSF Research Experiences for Undergraduates	Particle Physics
2004	Butler Summer Institute Butler University Research Endowment	Rotation of asteroids
2004	Cummins, Inc Columbus, Indiana	Heavy duty engineering, systems integration
2004	Indiana University Cyclotron, Bloomington NSF Research Experiences for Undergraduates	Particle Physics/ Detectors
2004	Diversified Systems Indianapolis, Indiana	Value Stream Mapping Custom Products Division Quality Department Control Plan for all areas in the Printed Circuit Board division
2004	Indiana University Purdue University at Indianapolis NSF Computational Neurophysics Laboratory J.H. Schild	Design and Development of numerical algorithms for neuronal action potential metrics calculations.
2004	Michigan State University NSF Research Experiences for Undergraduates	Interface Resistances in Sputtered Pd/Pt CPR-MR multilayers
2004	Delphi Grand Rapids, Michigan	Process Engineer Intern Analyzed and tracked fallout on assembly for new product launch of continuously variable cam phaser
2004	Science, Technology, and Society in Asia, Faculty-Student Research Grant from Freeman Foundation	Nanotechnology
2003	Eaton Corporation Greenfield, Indiana	Manufacturing Engineering Lean Manufacturing program (5S, TPM, and Value Stream Mapping)
2003	Butler Summer Institute Butler University Research Endowment	Dynamical Evolution of Core Collapsed Globular Clusters
2003	Butler Summer Institute Butler University Research Endowment	Design and Build of a Fiber Optic Spectrograph
2003	Butler Summer Institute Butler University Research Endowment	Intermediate Mass Black hole formation

Appendix 2. Doctoral programs our students have been accepted to in the last decade.

University of Alaska
University of Arizona
University of California Los Angeles
University of California San Diego
University of California Santa Barbara
Cambridge University
Columbia University
Cornell University
University of Florida
University of Illinois at Urbana-Champaign
University of Illinois at Chicago
Indiana University
IUPUI
Miami University
Michigan State University
University of North Carolina
Ohio State University
University of Pennsylvania
Purdue University
University of Texas at Austin
University of Texas at Houston
University of Wisconsin-Madison

Appendix 3. Publications and abstracts coauthored by students in the 2009-10 academic year.

1. "Monte-Carlo Fitting and Its Application in Electron Momentum Spectroscopy Data Processing", Zhang Zhe, Kyle Obergfell, Xianming L. Han, Chen Xiang-Jun, 2010 Acta Physica Sinica **59** 1695.
2. Mc Fall, M.J., & Ignace, R., "Modeling The Variation Of X-rays From Wolf-rayet Stars," *Bulletin of the American Astronomical Society* (2010).
3. Jones, M.L., Murphy, B.W., Phifer, K.A., Geiss, B., Mc Fall, M.J., & Cohn, H.N., "Depletion of Giant Stars in the Galactic Nucleus Due to a Top-Heavy Mass Function," *Bulletin of the American Astronomical Society* (2010).
4. Conroy, K.E, Darragh, A.N., Liu, Z.J., and Murphy, B.W., "Variable Stars in the Globular Cluster M14," *Bulletin of the American Astronomical Society* (2010).
5. Conroy, K.E, Darragh, A.N., Liu, Z.J., & Murphy, B.W., "Variable Stars in the Globular Cluster M14," to appear in the *Journal of the Southeastern Association for Research in Astronomy* (2010).
6. Murphy, B.W. Darragh, A., Harp, T., Liu, J., Geiss, B., Lawder, M., McFall, M., & Phifer, K.A., "Light Curve Analysis of Asteroids 6619 Kolya, 9549 Akplatonov, 12466 1997 AS12, 15154 2000 FW30, and 32505 2001 KF17," *submitted to the Minor Planet Bulletin*.
7. Geiss, B., Murphy, B.W, Phifer, K. A., McFall, M., Cohn**,** H.N., **"**The Effect of Stellar Collisions and Tidal Disruptions on Post-Main-Sequence Stars in the Galactic Nucleus." *Bulletin of the American Astronomical Society* (2010).
8. Phifer, K. A., Ghez, A.M., Yelda, S., & Do, T, **"**Obtaining An Unbiased Measurement of the Position Of SgrA*-IR." *Bulletin of the American Astronomical Society* (2010).
9. Murphy, B.W., Phifer, K. A., Cohn, H. N., & Lugger, P. M., "Mass Segregation in the Galactic Nucleus," *Bulletin of the American Astronomical Society*, 41, 226 (2009).
10. Phifer, Kimberly A., Murphy, B. W., Cohn, H. N., & Lugger, P. M., "Growth and Evolution of the Central Black Hole in the Galactic Nucleus," *Bulletin of the American Astronomical Society*, 41, 226 (2009).

2010 Theses:

Determination of energy level excitation states of time dependent optogalvanic signals in a discharge plasma. Michael Blosser
Modeling the Dynamics of Galactic Nuclei using the Fokker-Planck Method. Kim Phifer.

2010 Butler Undergraduate Research Conference:

Determination of Energy Level Excitation States of Time Dependent Optogalvanic Signals in a Discharge Plasma. Michael Blosser.
Study of intensity pattern of Fresnel diffraction through a circular aperture. Matthew Lawder
Modeling the Time-Dependence of Accretion of Mass by a Supermassive Black Hole from Stellar Evolution. Michael McFall.
Modeling the Dynamics of Galactic Nuclei using the Fokker-Planck Method. Kim Phifer.
Using Fourier Analysis to Determine the Rotation Period of Asteroids. Andrew Darragh.
Rotational Period of Main Belt Asteroids. Thomas Harp.
The Effect of Stellar Collisions and Tidal Disruptions on Post-Main-Sequence Stars in the Galactic Nucleus. Brian Geiss, Brian Murphy, Kim Phifer, & Michael McFall.
Modeling Bound States in the Continuum for Two Electrons in a Quantum Dot Pair. Thomas Tuegel.