Assessment of student learning

B.S. and B.A degrees in physics

A. Direct Methods

A.1 Capstone Course (PHYS 4991)

This course requires a technical writing sample and gives each student a nationally-normed exam, the physics subject GRE. It is offered in the spring and the fall of every year. Results from the spring of 2015 are summarized on table 1.

BA/ BS	Exam	Score	Paper	Next
BS	GRE	620	Honors Thesis	
BS	GRE	880	Senior Thesis	Ph.D. program in Physics at Baylor University
BS	GRE-UA	480	Senior Thesis	
BS	GRE-UA	500	Senior Thesis	Ph.D. program in ME at University of Illinois UC
BS	GRE-UA	500	Senior Paper	Work as an Energy Advisor for Panamanian Gov. In one year-Medical Physics MS in Costa Rica
BS	GRE-UA	520	Senior Thesis	Graduate School in Mechanical Engineering
BS	GRE-UA	520	Intro to Laser	July-Dec 2015: Basic Officer Leadership course, then pursue STEM job in industry
BS	GRE-UA	540	Honors Colloquium	Graduate School in Aerospace Engineering at UW in Seattle
BS	GRE-UA	560	Honors Thesis	Ph.D. in Chemistry at Washington University in St. Louis
BS	GRE-UA	580	Honors Colloquium	Work here at the U of A in Space Center for now and more classes.
BS	GRE-UA	590	Honors Thesis	Post-baccalaureate research at NIH
BS	GRE-UA	610	Senior Paper	Considering Law School, very strong LSAT score. Cancelled honors thesis and grad.
BS	GRE-UA	620	Honors Thesis	Ph.D. program in Aerospace Engineering at CU Boulder on fellowship
BS	GRE-UA	630	Senior Thesis	Job in Bolivia now, Graduate School in physics or engineering in a year
BS	GRE-UA	640	Honors Thesis	Ph.D. in Materials Science and Engineering at Georgia Tech
BS	GRE-UA	660	Senior Paper	
BS	GRE-UA	670	Honors Thesis	Get job, eventually grad school in ME or Biomedical
BS	GRE-UA	680	Senior Thesis	Working for a company and Graduate School in micro-EP

Table 1. Summary of results from capstone course, Spring 2015

A few comments are in order. The average of all the exam scores was 600, which is the minimum required for admission to graduate programs in physics at such institutions as Cornell University, Rensselaer Polytechnic Institute, or the University of Notre Dame (see data compiled by the American Institute of Physics here: http://www.gradschoolshopper.com/gradschool/browseby.jsp?q=3&cid=8). Moreover, we have reason to believe that students taking our "practice GRE" test (indicated above as "GRE-UA") do not work nearly as hard to prepare as when they are taking "the real

thing." Only a few students take the actual GRE (indicated simply as "GRE" in the table above), and not all of them report it back to us; for last spring, we only have data for two students, listed at the top of the table, and their average (750) is substantially higher than the overall average. This score is sufficient to be admitted to physics programs such as Georgia Tech or the university of California at Berkeley.

Now, having said this, we should also show the statistics for the students who took the capstone course in the fall of 2015, in Table 2 below:

	exam	**score**	**paper**
BS	GRE	480	REU research report
BS	GRE	570	publications with Salvador
BS	GRE-UA	390	MEEG term project
BS	GRE-UA	420	Honors Thesis
BS	GRE-UA	420	Report on his research with D. Kennefick
BS	GRE-UA	430	Report on his research with Bellaiche
BS	GRE-UA	450	Internship report
BS	GRE-UA	540	Eng Design & Analysis project

Table 2. Summary of results from capstone course, Fall 2015

Clearly, the results are much worse this time. The main reason for this is that in the Spring of 2015 an effort was made, in the course itself, to prepare the students for the practice GRE test, whereas the students in the fall took it "cold." This brings to light some problems with this particular assessment method, namely:

- The physics GRE is a very different kind of test from the exams that our students are used to (it is timed, for one thing), so it requires some practice and some strategy, in addition to just knowledge of physics, to do well in it. From this point of view, of course, it seems that it would always be best to provide the students with this kind of training in the capstone course, but:
- It is not easy to motivate the students to work hard to prepare for a practice test. Among other things, many of them will never want to or need to take the physics GRE, either because they are not planning to go to graduate school at all, or because they are planning to go in a different field (many of our students are double majors).

As a result of this, we are currently exploring other options for ways to quantitatively assess the student learning in our program.

A.2 Outcome Tracking

Due to the physics department's exceptional advising, strong personal contacts are formed with each student allowing evaluation of the immediate outcomes of the student and tracking of longitudinal outcomes. The immediate outcomes are indicated on table 1

for most of the students (on the column marked "Next"), although information on a few of them is still missing (data for the students represented in table 2, who would normally graduate in the Spring 2016, was not available yet at the time this report was put together). Clearly, our students are generally doing very well for themselves. Note in particular that some students who did not do particularly well in the "practice GRE" went on to be admitted at very good graduate schools, such as the University of Illinois at Urbana-Champaign or Washington University in St. Louis.

B. Indirect Methods

In addition to the information provided by statistics such as the ones presented above, our teaching effectiveness is continually being monitored in a number of indirect ways, such as: feedback from instructors of more advanced physics courses, feedback from students, various forms of external evaluation (physics honors thesis scores, nationally competitive awards to physics graduates), etc. We will mention here only a few of these, which we take as indication that we are, generally, doing very well by our students:

- Very good performance in the Honors Program. As the table above shows, at least 8 of the 17 students who took the capstone course in the spring of 2015 (that is to say, almost half) were enrolled in the Honors program and submitted some kind of Honors paper for their (required) technical writing sample.
- Our program was recognized by the American Institute of Physics by making their list of the relatively few research universities that graduate 20 or more physics majors per year (https://www.aip.org/statistics/table6). According to the American Physical Society data (see https://www.aps.org/careers/physicists/economics.cfm), a B.S. in physics is a very valuable degree, with an average starting salary (back in 2006) of $45,000. We are proud to be able to provide this value to so many (relatively speaking) University of Arkansas students.
- Our graduation and retention rates are very high. According to the Office of Institutional Research, our 1st year retention rate in the B.S. degree was 84.2% in 2014 (last year for which data are available), slightly above the university average, and our 6th year graduation rate was 80% for the class starting in 2009 (again, last year for which data are available), well above the university average.

C. Outlook

While the physics B.S. program appears to be thriving by most measures (we are a little down lately on the number of national awards, such as Goldwater scholarships, given to our individual students), the B.A. enrollment numbers are rather low (currently only 7, compared to 134 B.S., which is too few to present any meaningful statistics), and the continued usefulness of that degree is debatable. We intend to give this matter some serious consideration in the near future.

M.S. and Ph.D. degrees in physics

A. Direct Methods

A.1 For Ph.D. students: Candidacy Exam

The main instrument to assess student learning in the Ph.D. program is the departmental candidacy examination. All the Ph.D. students are required to take this examination no later than the spring of their second year in the program. The exam involves questions on the three core areas of mechanics, electricity and magnetism, and quantum mechanics, and thus tests directly the knowledge acquired by the students in those courses, which they take during their first three semesters in the department. The questions are submitted by the faculty and selected by faculty panels. The exams are administered every January, the week before classes begin. Each question is graded blind by two independent faculty members.

Students have two tries (on two consecutive years) to pass the exam, and they may pass individual sections separately. The data for the past four years is as follows:

2013: 17 takers, 4 passed, 2 failed
2014: 17 takers, 4 passed, 2 failed
2015: 13 takers, 7 passed, 3 failed
2016: 10 takers, 3 passed, 1 failed

Because it takes most students two tries, the 57 "takers" indicated above do not represent 57 separate students. Dividing this number by 2 one gets 28.5, which is close to the actual total number of decisions (26): over the course of these 4 years, 18 students passed and 8 failed, so an average passing rate may be computed as 18/26 = 69%, and the fail rate 8/26 = 31%.

The fact that 31% of our students fail the candidacy exam, despite its being a test over material that, in most cases, they have been taught in graduate courses in our own department, obviously raises some questions. Almost invariably, the students that fail are recognized by the faculty as "weak," and their failure almost never surprises anybody. It must be pointed out, however, that the candidacy exam in its present form is a test over theoretical knowledge; although most of us believe that this is knowledge that anyone with a Ph.D. in physics should have, the students may nonetheless have other skills that are not tested in the exam and that could be effective towards another kind of degree, especially one with a more applied or experimental emphasis. Indeed, many of the students who fail the candidacy exam end up joining the Ph.D. program in microelectronics and photonics (micro-EP) offered by the interdisciplinary Center for Nanoscience (located literally next door to our department), and many go on to do well there.

It is our understanding that the University is currently considering a substantial increase in the range of interdisciplinary degrees it will award. Based on our experience, we think this might be very helpful for some students.

At the same time, several faculty members believe that it is time to rethink the structure and purpose of the Candidacy Exam, and this is a debate we will probably be having in the very near future.

A.2 Annual reviews (both Ph.D. and M.S. students)

All students are required to undergo an annual review during which they present to their thesis or dissertation committee a summary of the work they have done over the year, both academic and in research. This is an opportunity for the committee to evaluate their academic trajectory, their general understanding of their research area (and related physics subjects) and their presentation skills.

The review is regularly used to identify possible problems or areas that need improvement. The responsibility for that action typically lies with the advisor, although occasionally the Chair or vice-Chair may feel the need to address a particularly serious situation (such as a conflict between the advisor and the student).

A sample of the review form, which is to be filled out by the advisor in consultation with the committee, is attached. For reference, over the past year the average rating in response to the two quantitative questions was as follows:

question (iv), "Please rank the student's progress made toward [graduation] over the past year." Average score: 4.4 out of 5,
question (v), "Please rank the overall quality of presentation." Average score: 4.1 out of 5.

This last question is important because one of our stated goals for the Physics graduate program is to "Develop the ability to communicate their work to a broad range of audiences."

A. 3 Thesis examination (M.S. students) or dissertation defense (Ph.D.)

Of course, the ultimate evaluation of the student's learning is the successful defense of a Masters' thesis or Ph.D. dissertation. Because of the many stages of "quality control" that the students go through before they reach that point, it is practically unheard of for a student not to pass his or her defense. Instead, poor or insufficient progress results in a delay of the defense.

As indicated above, most of the time the annual reviews result in an evaluation that the students are making satisfactory progress. Nonetheless, our time to graduation has stretched a bit over the past few years, if we go by the 7-year program reports. For our

2007-2014 program report we found an average time to degree of 6.1 years, which, while still below the national average of 6.4 years (as reported in the AIP document *Trends in Physics PhDs*, http://aip.org/sites/default/files/statistics/graduate/trendsphds-p-12.2.pdf), is higher than the 5.1 years that we reported in our previous assessment, for the period 2002-2006.

Our graduation rates are shown in the table below, along with enrollment data for comparison. All these figures are taken from the Office of Institutional Research.

Overall, enrollment and graduation numbers appear steady with a slight suggestion of multiyear growth. The entering Ph.D. cohort of 2015 was smaller than average, which may bias somewhat that year's enrollment data.

	2015	2014	2015-2014 average	2005-2015 average
Masters' enrollment	8	9	8.5	6.7
Masters' degrees awarded/yr	11	3	7	6.1
Ph.D. enrollment	34	42	38	36.7
Ph.D. degrees awarded/yr	3	5	4	3.2

B. Indirect Methods.

There are a number of indirect methods we use to assess the learning of our students, such as:

- Feedback from instructors of other graduate courses.
- Feedback from the graduate students themselves.
- For students who are TA's, student evaluations and other feedback.
- Research publications, conference presentations, research-related awards (e.g., at topical conferences).

Since most of this is of internal value only, we will only mention the last one here. An informal survey of the faculty indicates that over the year 2015, at least 14 Ph.D. students and 1 M.S. student were listed as co-authors in at least 21 distinct refereed publications. This represents a substantial fraction of our student body, and we believe it reflects well on the quality of the education, and the overall training, that the department provides.

Nonetheless, at the most recent (May 16, 2016) departmental retreat some of the younger faculty expressed a concern that our course load may be too high compared to other universities, and it takes too long for our students to be productive in research. This question is currently being considered by our Graduate Affairs Committee, and will almost certainly lead to significant changes in our program in the future.