

# Assessment of student learning

## Physics General Education Courses

### I. Introduction

As one of the central STEM disciplines, we provide a number of “service courses” to many students who are not our own majors. These range from required courses for engineering students to courses that fulfill the core science requirements for Fulbright and other colleges. These courses account for the majority of our SSCH.

Specifically, the following physics courses fall under the “general education” heading:

ASTR 2003/2001L, *Survey of the Universe* (introduction to astronomy for non-science majors).

PHYS 1023/1021L, *Physics and Human Affairs* (survey of physical ideas for non-science majors).

PHYS 1034, *Physics for Elementary Education Majors* (inquiry-based introduction to physics for future elementary school teachers; required by the College of Education).

PHYS 1044 and 1054, *Physics for Architects I and II* (a physics course specially designed for Architecture students).

PHYS 2013/2011L and PHYS 2033/2031L, *College Physics I and II* (“algebra-based” physics; taken primarily by students in the biological sciences).

PHYS 2054 and PHYS 2074, *University Physics I and II* (“calculus-based” physics, taken primarily by engineering students and students in the physical sciences).

### II. Goals:

- For students in technical, STEM majors, our main goal is to provide them with the basic knowledge of physics that they will require later on in either their academic career (to succeed in more advanced courses) or in the workplace.
- For students in other majors, our main goal is to provide them with some basic science knowledge and, above all, an appreciation of the value and the methods of science.

### III. Student Learning Outcomes

Students taking our service courses should be more scientifically literate and better able to understand and critically evaluate science issues as they affect society. In addition, students in a technical field should have the technical knowledge of physics and problem-solving skills necessary to do well in more advanced courses in their disciplines.

### IV. Assessment of student learning

#### IV.A Direct methods

Score gains between pre and post tests: this assessment instrument is used in most of our service courses. For University Physics I and II, the standardized FCI (Force Concept Inventory diagnostic test) and CSEM (Conceptual Survey of Electricity and Magnetism diagnostic test) are used. For Introduction to

Astronomy, the standard is the ADT (Astronomy Diagnostic Test), developed by the Collaboration for Astronomy Education Research (CAER). For College Physics, and Physics and Human Affairs, in-house developed tests are used. In all cases, the Hake gain is computed.

Results for AY 2015-2016:

ASTR 2003/2001L, *Survey of the Universe*  
Fall 2015: Hake gain: 22%. Spring 2016: 71%

PHYS 1023/1021L, *Physics and Human Affairs*  
Fall 2015: Hake gain: section 1, 17.8%; section 2, 31.1%, section 901 (online) 29.7%  
Spring 2016: section 901 (online) 27.6%

PHYS 2013/2011L and PHYS 2033/2031L, *College Physics I and II*  
Fall 2015 (College Physics I): Hake gain, 24%. Spring 2016 (College Physics II): Hake gain, 28%

PHYS 2054 and PHYS 2074, *University Physics I and II* (“calculus-based” physics, taken primarily by engineering students and students in the physical sciences).  
Fall 2015: 43% (UPI), 24% (UPII). Spring 2016: 52% (UPI)

#### IV.B Indirect methods

- Feedback from instructors of more advanced courses or academic advisors in the students’ colleges.
- Feedback from other sources (e.g., MCAT instructors)
- Feedback from students.

This year we do not have anything to report in the first two categories above, but we did receive, last Fall, a substantial amount of feedback from Honors students in the course PHYS 2013 (College Physics I), through the Fulbright College Honors Advisor. Some of this, and our response, is discussed in more detail below, in Section IV.D

#### IV.C Data collection and analysis

The pre and post assessment tests are collected every semester and the results are reported to the Department’s vice-Chair. There were several problems this year, mostly related to the replacement of our long-serving vice-Chair (Prof. Claud Lacy, who retired at the end of the Spring 2015), which resulted in data not being collected for some of those courses. In the near future, the department is considering the creation of a Service Courses Committee that will collect this information as well as the feedback from other sources, and make recommendations for assignments or curriculum changes to the rest of the department.

#### IV.D Use of results

The data collected above are used in many ways: at the individual instructor level, at the curriculum level, and when considering teaching assignments, for instance. In what

follows, we describe briefly the conclusions we have drawn from the results presented above, and the actions we have taken in response, where appropriate.

1. Hake gain results: although this has become, by now, a standard measure of learning gains, its significance is somewhat hard to quantify, since it depends on a number of factors, including the nature of the course considered and the method of instruction. Studies such as R. R. Hake, *Am. J. Phys.* 66, 64-74, 1998, indicate that for introductory Physics courses covering primarily classical mechanics, and making use of the FCI test—courses such as College Physics I and University Physics I in our program—“traditional” teaching methods typically result in a Hake gain of about 23%, whereas gains on the order of 48% are achievable with “interactive engagement” methods.

Our results, reported above, are broadly consistent with these observations. A particularly dramatic example is provided by our introductory Astronomy, which was taught as a conventional lecture in the Fall of 2015 and making use of interactive engagement methods in the Spring 2016. The Hake gain jumped by almost 50 points, from 22% to 71%. There are a number of considerations that suggest the latter figure should be taken with some caution

2. courses making use of the show that a gain of about 22% is typical for students of college physics, while  $0.52 \pm 0.10$  is possible with an "active learning" approach (R. R. Hake, *Am. J. Phys.* 66, 64-74, 1998).
3. At the curriculum level, we have spent many years perfecting our approach to the introductory physics courses, UPI and UPII, based on the Hake gain data as well as other empirical data, and the results of physics education research (in some cases conducted “in-house” by Drs. John and Gay Stewart). The result has been a curriculum that, while still continually being “tweaked,” boasts of substantial student learning gains and has been also validated by feedback from the engineering college, which claims that their students perform better in their advanced courses, after having taken our introductory physics sequence, than they did several years ago. The success of the U of A Physics department in revitalizing the Physics curriculum has been repeatedly recognized nationally, and was the subject of an article in *The American Journal of Physics* last year<sup>1</sup>.
4. An example of the ways in which we continually try to improve our curriculum in response to all the available data is provided by our online course offerings. The UPI and UPII data seem to indicate that online students of these courses do consistently worse than face-to-face students by a variety of measures, despite having otherwise entirely comparable homework, test and laboratory experiences. Accordingly, we are in the process of phasing out those online courses, as well as the College Physics ones. On the other hand, online students of Physics and Human Affairs (our general

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<sup>1</sup> “Revitalizing an undergraduate physics program: A case study of the University of Arkansas,” John Stewart, William Oliver III and Gay Stewart. *Am. J. Phys.* **81**, 943 (2013); <http://dx.doi.org/10.1119/1.4825039>

science core offering) do not seem to suffer from this problem, so we plan to keep our online version of this course and are, in fact, experimenting with introducing an online lab. We are also planning to develop an online version of Introduction to Astronomy, and when we start offering this course we will again monitor the Hake gain very closely.

5. The data may also be used to reassign instructors. As an example, a few years ago we were told by one of our alumni who prepares pre-med students for the MCAT that their knowledge of physics from the College Physics sequence was rather poor. This was consistent also with the very low Hake gains we saw for the course, and ultimately led to a national search for an appropriate instructor, with a background in biophysics, who could make the course more useful and interesting for the pre-med students.