Department of Physics – Report on Program and Learning Goals and Outcomes

1. Program Mission

The mission statement for the TTU Department of Physics is:

… to promote the learning of physics through effective teaching, research, and public service. Such learning opportunities are provided to students of all disciplines, in support of the mission of the University.

The department addresses this mission through two programs;

i) a coherent program of study leading to a B.S. in Physics, and

ii) a service program that provides courses in physics and astronomy that are requirements for other degree programs or are used by students to fulfill general education science requirements.

2. Goals and Objectives

2.1 Program Goals

1. Increase the number of physics majors (as determined at the beginning of each Fall Semester) to a 5-year average of over 20. This will be done through continued efforts at recruitment and retention.

2. Contribute to the mission of the proposed Center for Teaching and Learning in Science, Technology, Engineering, and Mathematics (STEM), by encouraging faculty members to become actively involved in the center.

3. To institute a regular seminar series in the department by asking faculty members to make presentations about their work, and to invite speakers from outside, as financing allows.

4. To improve the effectiveness of teaching assistants in introductory labs by assigning a faculty member to oversee their training and meet with them regularly.

5. To encourage faculty to reflect on their own teaching by making them aware of effective pedagogical developments coming from the physics education research community that may be relevant to their own classes.
2.2 Student Learning Goals

1. Students completing introductory physics courses will demonstrate increased understanding of certain basic concepts by achieving an average gain score of at least 40% on a standardized conceptual diagnostic test.

2. Students graduating in physics will demonstrate an understanding of the principles and foundations of physics, by having 75% of graduates score at or above the 75th percentile on the ETS Major Field Test.

3. Students graduating in physics will demonstrate the skills and techniques necessary to engage in experimental investigation, by having at least 75% of students achieve a grade of C or better in the capstone senior lab course (PHYS 4710).

4. Students graduating in physics will demonstrate the ability to communicate their understanding orally, as judged by a faculty committee who will report on oral presentations in the capstone senior lab course (PHYS 4710).

5. Students graduating in physics will have received an introduction to the technological tools appropriate to physics and related disciplines, as reported by alumni in surveys conducted periodically.

6. Students graduating in physics will have experience in basic or applied research, as determined by their participation in the research programs of departmental faculty, or in research programs at other institutions.

7. Students graduating in physics will agree that the program gave them sufficient preparation to continue to graduate school or obtain suitable employment, as reported by alumni in surveys conducted periodically.

3. Assessments Used

3.1 Assessments for Program Goals

a) Count Physics Majors (Assessment for Program Outcome 1)
   At the beginning of each Fall semester a count is made of the total number of enrolled students who have Physics declared as a major. Because of the small numbers involved, trends are tracked using an average of the current year plus the previous four years.
b) Examine faculty member involvement in STEM Center projects and Programs (Assessment for Program Outcome 2)
At the end of each academic year, a count is made of the number of actual, or proposed, projects and programs in which members of the Physics faculty were jointly involved with the Millard Oakley Center for Teaching and Learning in Science, Technology, Engineering, and Mathematics (STEM). This will include not only projects in which faculty members take a lead role, but also any professional development attended by faculty.

c) Count the number of seminars given in the department (Assessment for Program Outcome 3)
At the end of each academic year, count the number of seminars given by faculty members and invited guests.

d) Student Survey of Lab. Assistant Effectiveness (Assessment for Program Outcome 4)
At the end of each semester, students in laboratory courses will be asked to complete a short survey that addresses how effective the teaching assistant (TA) was in facilitating the operation of the laboratory and the role the TA played in their learning.

e) Self-reporting of teaching developments by faculty (Assessment for Program Outcome 5)
In their annual reports faculty members will be asked to comment on their awareness of new pedagogical developments and whether they have tried to implement them in their own teaching.

f) Video-taping of classes (Assessment for Program Outcome 5)
Once each academic year, every faculty member is video-taped teaching a class. The chair uses these video-tapes to assess a faculty member’s teaching in terms of the implementation of effective pedagogy. The tapes are also made available to the faculty members concerned to facilitate reflection on their own teaching.

3.2 Assessments for Student Learning Goals

a) Force Concept Inventory (Assessment for Student Learning Outcome 1)
This nationally recognized diagnostic test of basic conceptual understanding is administered to all students at the beginning of both PHYS 2010 and PHYS 2110 courses, and then again after the relevant material has been covered. The gain score, used to judge improvement in understanding, is a measure of the actual improvement in
performance after instruction, versus the maximum possible improvement.

b) ETS Major Field Test (Assessment for Student Learning Outcome 2)
All physics graduates will take the ETS Major Field Test in Physics during their final year at TTU.

c) PHYS 4710 Capstone Course (Assessment of Student Learning Outcomes 3 & 4)
All physics majors take this senior lab course. To be successful in this course students must synthesize many skills learned in their academic careers to date. They must engage in scientific investigation by planning and carrying out experiments, and they must use their physics knowledge to guide them and to interpret their results. They must also submit written reports of all their investigations and make a public oral presentation of one project at the end of the semester. Faculty present at these presentations will submit a report on them. A written summary of these reports, together with an assessment as to whether a particular student has met this outcome, will be compiled by the faculty member teaching the course, and placed in the student’s file.

d) Alumni surveys (Assessment of Student Learning Outcomes 5 & 7)
Surveys are administered to department alumni on a periodic basis. Among the questions asked are how well graduates felt the TTU physics program prepared them for their chosen career path, and how effectively they were introduced to appropriate technological tools.

e) Participation in Research Programs (Assessment of Student Learning Outcome 6)
The department will keep a record of student participation in the research of department faculty members and in specialized summer research programs for undergraduates at other institutions. (Note: since almost all such experiences must necessarily take place during the summer it is impossible to ensure that all students will take advantage of such opportunities. However, the department will encourage such participation as actively as possible.)
4. Results of Assessment

Program Goal 1: (Data collected yearly.) The number of physics majors has risen steadily over the last 6 years, with the rolling 5-year average rising from 19 to 33. Because of this we have gradually increased our targeted number of physics majors so that the goal is now to achieve a five-year average of 40.

Program Goal 2: (Data collected yearly.) Physics faculty have made increasing use of the STEM Center since its establishment. In the last year the department has:
- Taught four different courses using the STEM Center facilities.
- Been PI or co-PI on two different NSF grants run administered by the STEM Center.
- Instructed in two professional development workshops for K-12 teachers run by the STEM Center.
- Assisted in several informal outreach programs.

Program Goal 3: (Data collected yearly until abandonment.) Due to increasing teaching loads we have found it impossible to establish a regular seminar series by our own faculty. Lack of resources also limits our ability to invite external speakers. Due to these limitations we have essentially abandoned this goal.

Program Goal 4: (Data collected yearly until focus of goal revised.) In 2006/7 a faculty member met regularly with current lab TAs. However, a survey of students in introductory lab classes revealed that they were already very happy with their TAs, but less satisfied with the structure of the labs themselves. For this reason we have shifted our focus from the TAs, who now meet with individually assigned faculty, to the gradual restructuring of our lab classes to be more inquiry-based.

Program Goal 5: (Data collected yearly.) Starting in 2005, the number of faculty members trying different approaches in their teaching has been rising gradually. Since 2009 all faculty members have reported trying different strategies, ranging from simply making lecture notes available to students, to fully implementing studio-style instruction. The department chair reviews the annual video recordings of faculty teaching and three faculty now regularly review their own recordings and reflect on them. Discussions of pedagogical developments now regularly take place between faculty members and six of seven faculty are now considered to be employing some form of active learning in at least one of their classes.
Learning Goal 1: (Data collected each semester.) On adopting this goal many faculty members made changes to their instruction to address it. As a consequence, the average gain in PHYS 2110 rose almost immediately from 30% to slightly over 40% but since then has remained level (or even fallen slightly). In PHYS 2010 the average gain showed no such improvement, remaining well below 30% despite the changes in instruction. However, with NSF grant support, two faculty members have since developed a guided-inquiry style curriculum for the PHYS 2010 course and the average gain for these pilot sections has been around 55%.

Learning Goal 2: (Data collected yearly.) From 1989 to the present, almost 75% of our graduates have scored at or above the 75th percentile on the MFAT, which is deemed to be a good indication of the quality of our program. However, in recent years the rolling 3-year average has fallen below this level and so we continue to maintain this goal as a long term aim and use annual statistics to monitor the quality of our graduates. Fig. 1 and Table 1 below summarize the performance of TTU Physics Majors on the MFAT. (There were no graduates from the program in 2002 and 2003.)

![Figure 1](image.png)

*Fig 1. Three-year rolling average of absolute MFAT scores for TTU Physics Majors versus the national average.*
Table 1. Three year rolling average of mean percentile placing of TTU Physics majors on MFAT, with percentage of those achieving at or above the 75th percentile.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number in 3-year sample</th>
<th>3-year average percentile</th>
<th>Fraction of students Achieving 75th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>6</td>
<td>80%</td>
<td>67%</td>
</tr>
<tr>
<td>1992</td>
<td>4</td>
<td>89%</td>
<td>100%</td>
</tr>
<tr>
<td>1993</td>
<td>7</td>
<td>89%</td>
<td>86%</td>
</tr>
<tr>
<td>1994</td>
<td>6</td>
<td>93%</td>
<td>83%</td>
</tr>
<tr>
<td>1995</td>
<td>8</td>
<td>81%</td>
<td>63%</td>
</tr>
<tr>
<td>1996</td>
<td>6</td>
<td>81%</td>
<td>67%</td>
</tr>
<tr>
<td>1997</td>
<td>6</td>
<td>74%</td>
<td>50%</td>
</tr>
<tr>
<td>1998</td>
<td>4</td>
<td>79%</td>
<td>50%</td>
</tr>
<tr>
<td>1999</td>
<td>4</td>
<td>76%</td>
<td>50%</td>
</tr>
<tr>
<td>2000</td>
<td>5</td>
<td>83%</td>
<td>60%</td>
</tr>
<tr>
<td>2001</td>
<td>9</td>
<td>86%</td>
<td>78%</td>
</tr>
<tr>
<td>2004</td>
<td>4</td>
<td>78%</td>
<td>75%</td>
</tr>
<tr>
<td>2005</td>
<td>5</td>
<td>78%</td>
<td>80%</td>
</tr>
<tr>
<td>2006</td>
<td>9</td>
<td>83%</td>
<td>89%</td>
</tr>
<tr>
<td>2007</td>
<td>8</td>
<td>73%</td>
<td>75%</td>
</tr>
<tr>
<td>2008</td>
<td>12</td>
<td>69%</td>
<td>60%</td>
</tr>
<tr>
<td>2009</td>
<td>12</td>
<td>57%</td>
<td>33%</td>
</tr>
<tr>
<td>2010</td>
<td>12</td>
<td>60%</td>
<td>42%</td>
</tr>
<tr>
<td>2011</td>
<td>11</td>
<td>64%</td>
<td>64%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>56</td>
<td>75%</td>
<td>75%</td>
</tr>
</tbody>
</table>

Learning Goal 3: (Course grade data collected yearly. Alumni survey approximately every 5 years.) While we are easily achieving this goal, in terms of course grades, a 2009 survey of alumni revealed a slight decrease in their perceived preparation in experimental skills among recent graduates. We are watching this carefully, with the chair explicitly addressing it in exit interviews with graduating seniors.

Learning Goal 4: (Data collected yearly.) In 2005 we implemented specific strategies to help our students achieve this goal. Since then we have seen a marked improvement in student performance, with well over 75% being judged proficient in oral presentation and communication skills.

Learning Goal 5: (Data on implementation collected every semester. Alumni survey approximately every 5 years.) Our most recent alumni survey (Fall 2008) revealed that lack of emphasis on computational techniques was a
perceived weakness of the program. We therefore developed a coordinated program to address it as one of the initiatives proposed in our 2009 academic audit. We are now in the second year of implementation of this plan.

Learning Goal 6: (Data collected yearly.) As of 2011 almost all students who seek such summer research experiences have obtained them. We continue to encourage students to seek out summer research programs and make students aware of possibilities nationwide.

Learning Goal 7: (Alumni survey approximately every 5 years.) The latest alumni survey (Fall 2008) showed that our graduates were overwhelmingly satisfied that the program gave them a good preparation for their next career step (average score of 4.8 on a 5 pt rating scale!)
5. Achievements and Impact

Program Goal 1
With the low numbers of students declaring physics as a major there are large statistical fluctuations in the year-to-year totals. However, the five-year average revealed a downward trend, from a high of 20 in the year 2000 to a low of 14 in 2003. In response to the start of this trend the department implemented a more proactive and personalized recruiting strategy that was continued during this planning period, and seems to have been successful. For the Fall 2011 semester we had our largest ever freshman class of 14, taking the number of declared physics majors to an all-time high of 42.

Student Learning Outcome 1
For the five years prior to this planning period, the average gain score in the conceptual diagnostic test was 22% in PHYS 2010, and 29% in PHYS 2110. Such scores are typical nationwide for traditional lecture-based courses. However, research in physics education has shown that significant improvements in conceptual understanding can be achieved by employing interactive engagement techniques in the classroom. Therefore, at the beginning of this planning period, faculty were encouraged to adopt such techniques in their introductory classes. Efforts in this direction were (and continue to be) considered as part of the annual faculty evaluation.

The students of those faculty that did adopt such approaches in the PHYS 2110 class, initially showed gain scores that consistently approached, or even exceeded, the adopted target of 40%. These results were shared with the rest of the faculty, who were encouraged to try them in their own classes and the initially encouraging improvement was maintained for several semesters. (See Fig. 2) However, since then there has been a disappointing downward trend, the reason for which is not entirely evident. Therefore, as one of the outcomes of the recent academic audit process we are now making more detailed feedback about the diagnostic test results available to the faculty in order they may target their instruction on specific student misconceptions. In another effort to address student learning, we are currently piloting an inquiry-based curriculum in one section of PHYS 2110. We await the aggregation of enough data to determine if these interventions are having any effect.
Unfortunately, as can be seen in Fig. 2, the adoption of interactive engagement techniques in the PHYS 2010 lecture class in 2005 did not have the same dramatic effect as it did in PHYS 2010. This prompted two of the faculty to apply for (and receive) NSF funding to support the development of a new, inquiry-based, curriculum for this course. Encouragingly, the diagnostic test gain score of students taking this curriculum has consistently been above the 40% target, and often above 50%. (Again, see Fig. 2) We are therefore currently seeking funding to continue its development, and find ways to implement it in all sections of the PHYS 2010 course.

**Student Learning Outcome 5**

As technology advances new tools continuously become available and the department is aware that computational physics is an expanding, and increasingly important, field. Previously it was left to individual faculty to introduce computational techniques to students in their courses as they felt appropriate. However, our latest alumni survey revealed that the lack of specific emphasis on computational techniques was a perceived weakness of the program, and so the faculty decided to increase the emphasis on this developing area of physics within the degree program.
One approach considered was to simply add a specific Computational Physics course to the program of study. However, due to limited resources, it was realized that doing so would have to be at the expense of reducing hours elsewhere in the program. Therefore, as one of the initiatives proposed in our 2009 academic audit, we proposed developing a coordinated plan to expose students to computational techniques throughout their program of study, within the courses they already take. A subgroup of faculty met several times and developed such a plan, culminating in a capstone computational experience embedded within the Advanced Modern Physics class taken in the senior year. We now have our first cohort of students engaged in this coordinated approach and we await the results.