Tennessee Tech University

**Final Annual Report**

**Tennessee Tech University**

**President**

**Provost**

**College of Arts and Sciences**

**Physics**

## Physics Department Mission Statement

**Department/Unit Contact:** Steve Robinson

**Mission/Vision/Goal Statement**

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.

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## Learning Outcome 1 - Diagnostic Test

**Define Goal**

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.

**Intended Outcomes / Objectives**

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## Learning Outcome 2 - Major Field Test

**Define Goal**

Students graduating in physics will demonstrate an understanding of the principles and

foundations of physics, by having graduates score, on average, at or above the 75th percentile on the ETS Major Field Test in Physics.

**Intended Outcomes / Objectives**

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## Learning Outcome 3 - Experimental Skills

**Define Goal**
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).

**Intended Outcomes / Objectives**

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## Learning Outcome 4 - Oral Presentation

**Define Goal**
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).

**Intended Outcomes / Objectives**

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## Learning Outcome 5 - Technological Tools

**Define Goal**
Students graduating in physics will have received an introduction to the technological tools appropriate to physics and related disciplines, as reported by graduating physics majors in exit interviews and by alumni in surveys conducted periodically.

**Intended Outcomes / Objectives**

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## Learning Outcome 6 - Career Preparation

**Define Goal**

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 graduating physics majors in exit interviews and by alumni in surveys conducted approximately every five years.

**Intended Outcomes / Objectives**

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### Program Goal 1 - Number of Majors

**Define Goal**
Increase the number of physics majors (as determined at the beginning of each Fall Semester) to a 5-year average of 50. This will be done through continued efforts at recruitment and retention.

**Intended Outcomes / Objectives**
Approved - Nat

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### Program Goal 2 - STEM Center

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

**Intended Outcomes / Objectives**

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### Program Goal 3 - Undergraduate Research

**Define Goal**
Facilitate physics majors in gaining experience in basic or applied research, by encouraging their participation in the research programs of departmental faculty, or in summer research programs at other institutions.

**Intended Outcomes / Objectives**

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Tennessee Tech University

## Program Goal 4 - Teaching Reflection

**Define Goal**
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.

**Intended Outcomes / Objectives**

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### Tool 1 - Count Physics Majors

**Goal/ Outcome/ Objective:** Program Goal 1
**Type of Tool:** Other

**Rationale**
At the beginning of each fall semester a count is made of the number 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.

**Frequency of Assessment:** Beginning of every fall semester

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### Tool 10 - Exit Interviews

**Goal/ Outcome/ Objective:** Learning Outcomes 5 & 6
**Type of Tool:** Other

**Rationale**
Because of the delay in feedback via alumni surveys, we have now decided to also address these student learning outcomes with students who are getting ready to graduate from the program. While these students do not have the benefit of post-program experience, they do have a fresher recollection of their TTU courses and so can provide valuable feedback on some elements of the program. The department chair already conducts a confidential exit interview with each graduating physics major. However, beginning in 2013, these interviews are explicitly addressing how well prepared each student feels for their next career step, including their preparation in the use of technological tools.

**Frequency of Assessment:** As necessary for graduating seniors

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### Tool 2 - Examine STEM Center Involvement

**Goal/ Outcome/ Objective:** Program Goal 2

**Type of Tool:** Survey

**Rationale**
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.

**Frequency of Assessment:** End of each academic year

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### Tool 3 - Research Involvement
**Goal/ Outcome/ Objective:** Program Goal 3
**Type of Tool:**

**Rationale**
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.)

**Frequency of Assessment:** End of each academic year

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### Tool 4 - Teaching Developments
**Goal/ Outcome/ Objective:** Program Goal 4
**Type of Tool:**

**Rationale**
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.

**Frequency of Assessment:** End of each academic year

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### Tool 5 - Video of Classes
**Goal/ Outcome/ Objective:** Program Goal 4
**Type of Tool:**

**Rationale**
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.

**Frequency of Assessment:** Once per academic year

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**Tool 6 - Force Concept Inventory**
**Goal/ Outcome/ Objective:** Learning Outcome 1
**Type of Tool:** Other

**Rationale**
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.

**Frequency of Assessment:** Beginning and end of each semester

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**Tool 7 - Major Field Test**
**Goal/ Outcome/ Objective:** Learning Outcome 2
**Type of Tool:** Exit Exam

**Rationale**
All physics graduates will take the ETS Major Field Test in Physics during their final semester at TTU.

**Frequency of Assessment:** When necessary for graduating seniors

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**Tool 8 - PHYS 4710 Capstone Course**
**Goal/ Outcome/ Objective:** Learning Outcomes 3 & 4
**Type of Tool:** Capstone Project

**Rationale**
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.

**Frequency of Assessment:** When necessary for graduating seniors

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### Tool 9 - Alumni Survey

**Goal/ Outcome/ Objective:** Learning Outcomes 5 & 6
**Type of Tool:** Survey

**Rationale**
Because of the low number of physics graduates, these surveys are administered to department alumni on an approximate 5-year cycle. 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. (The most recent results available are from the survey conducted in Fall 2014 in conjunction with the department's scheduled academic audit.)

TTU Physics Alumni Survey

**Frequency of Assessment:** Approximately every five years

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### Result 1 - Number of Physics Majors

**Goal/Objective/Outcome Number:** Program Goal 1

**Results**
The number of declared physics majors at the start of the Fall 2016 semester was 29. This is th elowest number for several years!

**Attachments**
No items to display.

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### Result 10 - Exit Interviews

**Goal/Objective/Outcome Number:** Learning Objectives 5 & 6

**Results**
In interviews conducted just before graduation three seniors expressed general satisfaction with their preparation at TTU. Addressing the department goal of giving students a good grounding in computational techniques, they were all of the opinion that they had received a good grounding in the use of commercial software and in the skills needed to write their own, or adapt existing, code. This is significant because computational skills is an area of weakness identified previously, and that the

department has addressed with a specific course of action over the past few years.

**Attachments**
No items to display.

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**Result 2 - STEM Center Involvement**
**Goal/Objective/Outcome Number:** Program Goal 2

**Results**
Physics faculty involvement in projects and programs associated with the Millard Oakley STEM Center (MOSC) has continues at a higher level. During the past year one faculty member taught a complete course using the MOSC facilities, making continued use of the video recording system to document the implementation of new curriculum materials. In addition one faculty member was the PI on one, and two were co-PIs on externally funded programs administered by MOSC. Four physics faculty and six students were involved in three different public outreach events offered by MOSC.

**Attachments**
No items to display.

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**Result 3 - Student Research**
**Goal/Objective/Outcome Number:** Program Goal 3

**Results**
With a significant increase in external funding for research, during this year a total of fourteen individual undergraduate students participated in research activities of various types with department faculty members. This substantial increase in student involvement reflects the department's emphasis on potential undergraduate research involvement as a requirement for our most recently hired tenure-track faculty.

**Attachments**
No items to display.

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**Result 4 - Teaching Developments**
**Goal/Objective/Outcome Number:** Program Goal 4

**Results**
During this year several developments in instruction occurred in the department:

- All sections of PHYS 2010/2020 were taught using the innovative guided-inquiry LEAP curriculum for Algebra-based Physics, developed at TTU with grant support from the National Science Foundation.
- A new faculty member member taught PHYS 2010 and PHYS 2020 using the LEAP curriculum materials.
- All faculty members teaching PHYS 2110 and PHYS 2120 incorporated some degree of active learning strategies ('flipped' class, group problem solving, and others).
- Two faculty members implemented QEP projects, one to incorporate practical group projects in PHYS 2110, the other to incorporate computational exercises in PHYS 2120.
- The supplemental instruction (SI) program targeting the PHYS 2110 course was transitioned to a Class Plus program operated by Learning Support in the Volpe Library.Models to identify 'at-risk' students in PHYS 2110 and PHYS 2120 were further refined.

**Attachments**
No items to display.

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**Result 5 - Video of Classes**
**Goal/Objective/Outcome Number:** Program Goal 4

**Results**
No classroom video was recorded again this year because of time pressure imposed by various administrative functions.

**Attachments**
No items to display.

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**Result 6 - Force Concept Inventory**
**Goal/Objective/Outcome Number:** Learning Outcome 1

**Results**
In the 2016/2017 academic year four of ten sections of PHYS 2110 achieved the goal of a g above. The average gain over all ten sections was 37%. The five semester rolling average goal for the first time in ten years.

In PHYS 2010 all sections were taught with the guided-inquiry LEAP curriculum. Five of the achieved the departmental goal of a 40% gain, with the average over all sections being 43%

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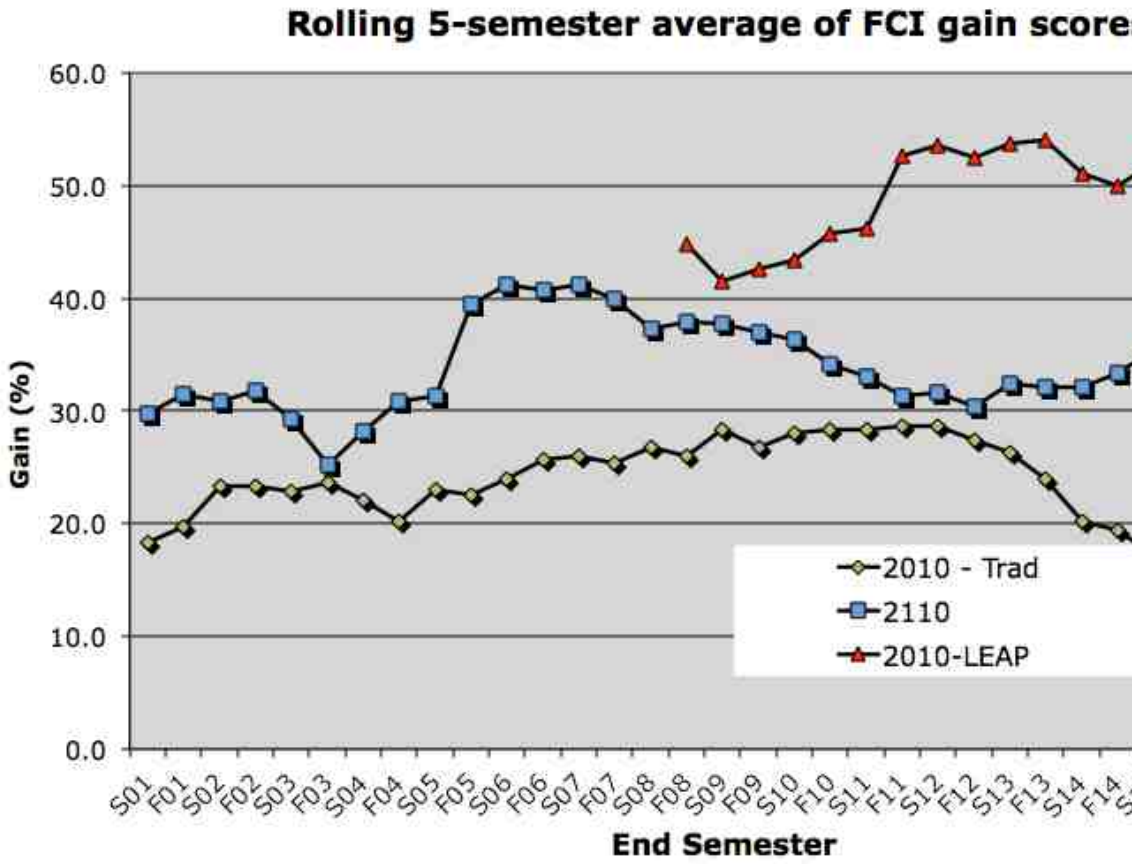
The graph below shows the rolling 5-semester average of FCI gains in relevant courses.




**Attachments**

FCI_report_2017

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**Result 7 - Major Field Test**

**Goal/Objective/Outcome Number:** Learning Outcome 2

**Results**

Three students took the Major Field Test in Physics this year; scoring at the 76$^{th}$ percentile on average. Our three-year average percentile currently stands at 84%, which comfortably exceeds the department goal of an average of the 75$^{th}$ percentile and continues the recent overall upward trend. This puts the TTU physics program in the top 3% of institutions that use this test to measure student achievement.

**Attachments**

Tennessee Tech University

No items to display.

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**Result 8 - Capstone Course**

**Goal/Objective/Outcome Number:** Student Learning Outcomes 3 & 4

**Results**

Five students completed the capstone Advanced Lab course (PHYS 4710/4720) this year. All earned a grade of C or above, demonstrating their competence in the skills and techniques of experimental investigation. This surpasses the goal of having at least a 75% success rate. As judged by the faculty attending their end of semester presentations, all five also demonstrated the ability to communicate their understanding orally.

**Attachments**

No items to display.

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**Result 9 - Alumni Survey**

**Goal/Objective/Outcome Number:** Learning Outcomes 5 & 6

**Results**

Due to the low numbers of graduates we only conduct this survey every 5 years. The last survey was completed in Fall 2014 and a report on that survey is attached.

**Attachments**

PHysics Alumni Survey - 2014

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**Change Related to Program Goal 1 - Restructuring of Program of Study for Applied Physics Option**

**Goal/Objective/Outcome Number:** Program Goal 1

**Program Changes and Actions due to Results**

The program of study for the BS in Applied Physics (Option II) is includes 14 credit hours comprising a set of coordinated courses in other technical disciplines agreed upon by the advisor. To supplement the rather nebulous requirement this we have developed more directed programs of study that fit within this framework. Last year programs with emphases in Biology, Chemistry, Computer Science, and Earth Sciences, were developed. This year a fifth program with an emphasis in pre-medical studies was added. All these programs were presented to prospective students during the past year, but we

have yet to know whether this has resulted in increased recruitment.

**Link to Assessment**
The development of these programs of study is intended to give prospective and current students more specific interdisciplinary options, while still pursuing a degree in physics. In this way we hope to attract and retain more physics majors.The 2017/18 academic year is the first in which these program emphases will be implemented and so we will monitor how many students follow them over the coming years.

**Link to Flight Plan:** Enrollment, Tuition, and Scholarships, Improve Undergraduate Student Experience

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**Change Related to Program Goal 2 - Student Involvement in STEM Center Activities**
**Goal/Objective/Outcome Number:** Program Goal 2

**Program Changes and Actions due to Results**
Increasing numbers of physics majors are volunteering to help with outreach activities at the STEM Center. Up to now we have only tracked faculty involvement in STEM Center programs, but going forward we will also track student involvement. Program Goal 2 will be changed for the coming year to reflect this.

**Link to Assessment**
Goring forward, assessment of Program Goal 2 will include counting the numbers of both physics faculty and students involved in STEM Center programs.

**Link to Flight Plan:** Undergraduate Co-Curricular Program

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**Change Related to Program Goal 3 and Learning Outcome 6.**
**Goal/Objective/Outcome Number:** Program Goal 3 and Leanring Outcome 6.

**Program Changes and Actions due to Results**
The department's proposal to include a research experience as part of the physics program of study has now been approved. Starting in the 17/18 academic year physics majors will take two research oriented courses during their senior year. The department goal of giving students a research experience will thus be transformed into a learning objective consistent with the proposed outcomes for these courses.

**Link to Assessment**
Up to now research experiences have been limited to voluntary participation during the academic year and the summer. With three new research-active faculty joining the department we have now shown that enough opportunities can be provided for all physics undergraduates to gain research experience (Tool 3, Result 3).

**Link to Flight Plan:** Improve Undergraduate Student Experience, Create Distinctive Programs and Invigorate Faculty

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**Change related to Learning Outcome 1 and Program Goal 4 - Active Learning in Calculus-based Introductory Classes**

**Goal/Objective/Outcome Number:** Program Goal 4 and Learning Outcome 1

**Program Changes and Actions due to Results**
All faculty members are now implementing some degree of various active-learning strategies in their assigned sections of the Calculus-based Physics courses (PHYS 2110 and PHYS 2120).

**Link to Assessment**
Having experimented with various active learning strategies, and the benefits they bring to student learning, all faculty have now adopted such techniques to various degrees.

**Link to Flight Plan:** Improve Undergraduate Student Experience

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**Change related to Learning Outcome 1 and Program Goal 4 - Adoption of LEAP Curriculum**

**Goal/Objective/Outcome Number:** Program Goal 4 and Learning Outcome 1

**Program Changes and Actions due to Results**
Last year we offered all sections of PHYS 2010 and PHYS 2020 using the LEAP curriculum format. In the coming year we will revert to offering a single section in the traditional lecture/lab format.

**Link to Assessment**
Students using the LEAP curriculum in the PHYS 2010 course show superior performance
on the Force Concept Inventory diagnostic test (Tool 4, Results 4) consistently surpassing the
department goal of a gain of 40% (Learning Objective 1), whereas those in traditionally taught
sections do not. However, in offering all courses in this format we found that some students could not fit the three 2-hours blocks required into their class schedules. We will therefore revert to offering one more traditionally-structured sections until we can consider restructuring the LEAP curriculum to accommodate such restrictions.

**Link to Flight Plan:** Improve Undergraduate Student Experience