

## Physics BS: 2019-2020

### Definition of Unit

#### Providing Department:

Physics

#### Department/Unit Contact:

Steve Robinson

#### Mission/Vision 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.

### Learning Outcome 1 - Student Learning in Introductory Courses

#### Define Goal:

Students completing calculus-based and algebra-based introductory physics courses will demonstrate increased understanding of foundational basic concepts in mechanics.

#### Intended Outcomes / Objectives:

Understanding of basic mechanics concepts will be measured using the normalized gain on a standard diagnostic test used at many institutions nationwide. For many years the targeted goal was a gain of 40%, but with recent improved performance, this year the target was raised to 45%. Currently, the minimum acceptable performance for any particular class section is a 30% gain, and any gain greater than 50% is regarded as exemplary.

DRILL DOWN-----

RELATED ITEM LEVEL 1

### Learning Outcome 1: Assessment - Force Concept Inventory

#### Frequency of Assessment:

Beginning and end of each semester

#### Rationale:

The Force Concept Inventory is a nationally recognized diagnostic test of basic conceptual understanding and 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 normalized gain score, used to judge improvement in understanding, is a measure of the actual improvement in performance after instruction, versus the maximum possible improvement.

#### RELATED ITEM LEVEL 2

### **Learning Outcome 1: Results - Force Concept Inventory (FCI)**

#### **Results:**

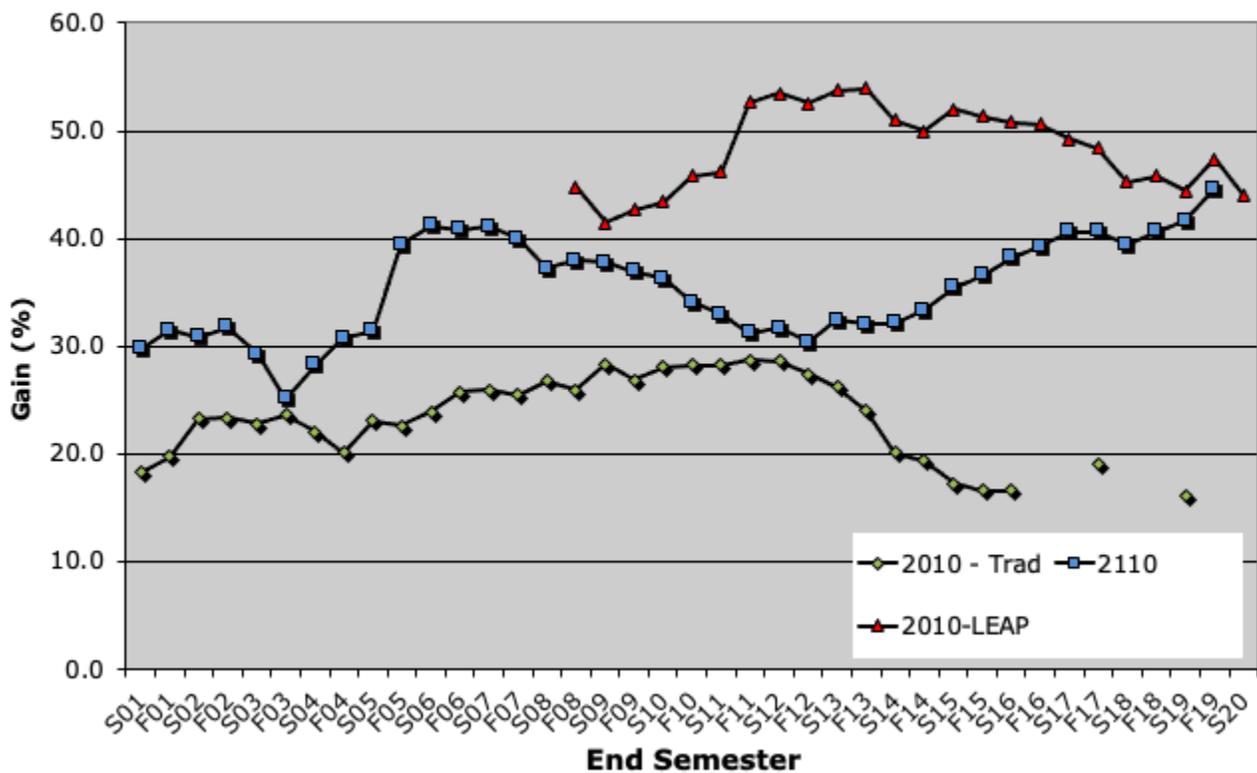
In the Fall 2019 semester 4 of 5 face-to-face sections of PHYS 2110 achieved the new goal of a normalized gain of 45% (though uncertainties are extremely high due to very low statistics). The average gain of all 6 sections (five face-to-face, plus one online section being taught for the first time) was approximately 58%. After the fall semester, the rolling 5-semester average gain stood at 44.8% already approaching the new goal! Unfortunately, the disruption caused by the COVID-19 pandemic meant that we could not gather any data for this course, so we will have to wait to see if this trend continues.

Turning to PHYS 2010 all 3 fall sections taught using the guided-inquiry LEAP curriculum surpassed the 45% goal, with an average gain of 55%, the highest it has been for two years. This may be due to deliberate attempts on the part of the faculty in this course to re-emphasize conceptual understanding. However, we will have to wait because, although data was collected in the spring, it cannot be seen as indicative due to the sudden transition to an online format for what is essential a 'hands-on' course.

We continue to offer one section of PHYS 2010 in the more traditional manner but low numbers mean that no meaningful data could be collected in either semester..

The graph below shows the rolling 5 semester average of FCI gains in relevant courses and a fuller report on a continuing longitudinal study is attached.

**Rolling 5-semester average of FCI gain scores**



**Attachments:**

FCI\_report\_2020.pdf

**Learning Outcome 2 - Learning of Physics Majors**

**Define Goal:**

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

**Intended Outcomes / Objectives:**

Graduating seniors will score, on average, at or above the 75<sup>th</sup> percentile on the ETS Major Feld Test in Physics. The threshold of acceptability is to have all seniors score at or above the 50<sup>th</sup> percentile, thus maintaining a claim that TTU physics graduates are 'above average'.

DRILL DOWN-----

RELATED ITEM LEVEL 1

## **Learning Outcome 2: Assessment - Major Field Test**

### **Frequency of Assessment:**

When necessary for graduating seniors

### **Rationale:**

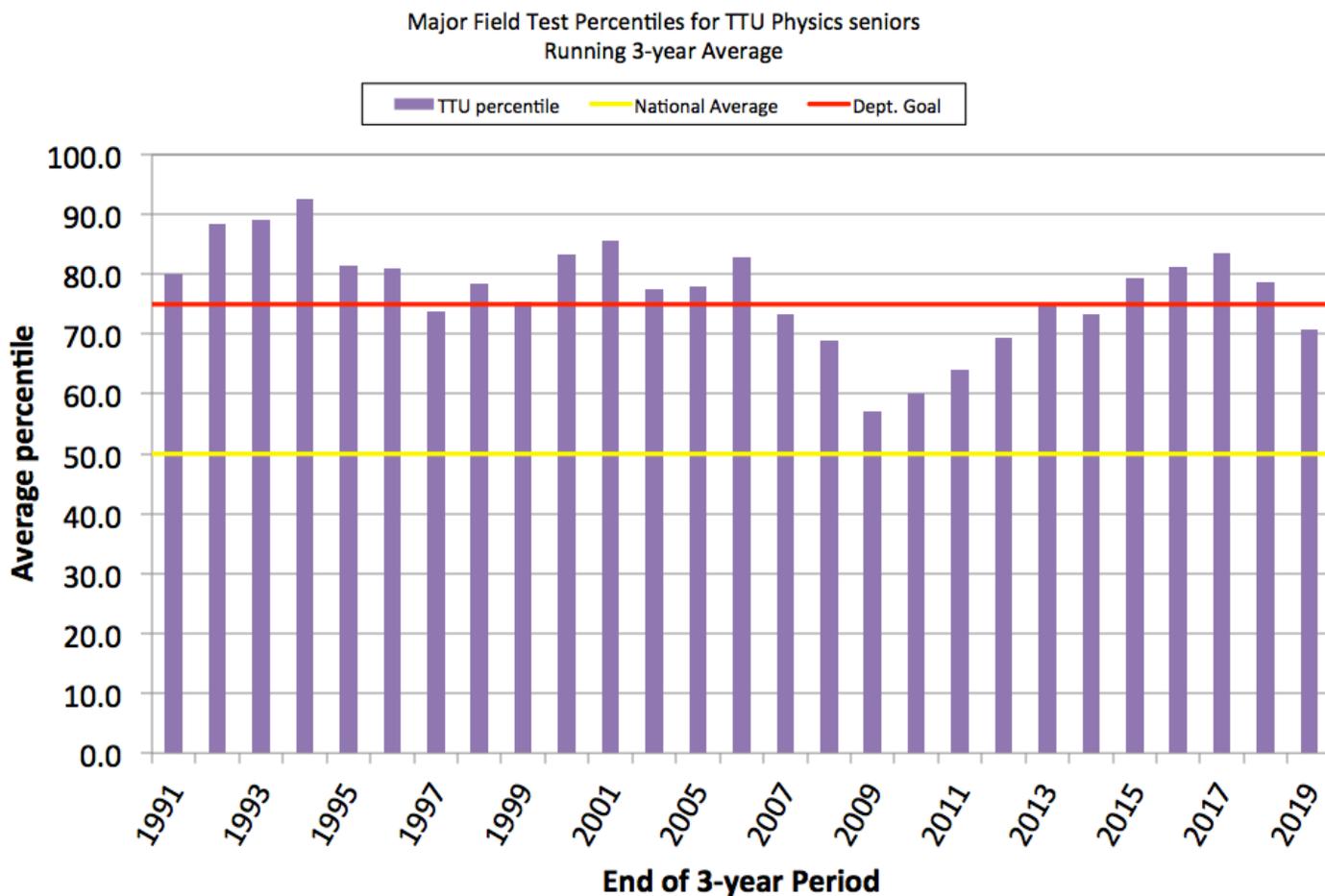
The ETS Major Field Test in Physics is a 70 item multiple-choice test that covers: Classical Mechanics and Relativity; Electromagnetism; Optics and Wave, Thermodynamics and Statistical Mechanics; Quantum Mechanics and Atomic Physics; and other Special Topics. All physics graduates will take the ETS Major Field Test in Physics during their final semester at TTU. Due to a low number of students, only two sub-scores are provided with the Exit exam results.

RELATED ITEM LEVEL 2

## **Learning Outcome 2: Results - Major Field Test**

### **Results:**

Unfortunately, due to the COVID-19 situation, the two graduating seniors who had not already taken the Major Field Test were not able to do so. (The third had already taken the test in the previous year, scoring at the 93rd percentile.) Thus we will have to wait until next year to see whether last year's dip below the targeted goal (a three year average of the 75th percentile) was a temporary 'blip'.



**Attachments:**

### **Learning Outcome 3 - Experimental Skills**

**Define Goal:**

Students graduating in physics will demonstrate the skills and techniques necessary to engage in authentic experimental investigation.

**Intended Outcomes / Objectives:**

Students will demonstrate their ability to engage in experimental investigations by meeting or exceeding the minimum standards of the capstone Advanced Experimental Physics course (PHYS 4710 or PHYS 4711). The targeted outcome is that at least 75% of students should meet or exceed the minimum standards.

DRILL DOWN-----

RELATED ITEM LEVEL 1

### **Learning Outcome 3: Assessment - PHYS 4710/4711 Capstone Course**

#### **Frequency of Assessment:**

When necessary for graduating seniors

#### **Rationale:**

All physics majors take a senior lab course, either PHYS 4710 (4 cr) or PHYS 4711 (2 cr). 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.

RELATED ITEM LEVEL 2

### **Learning Outcome 3: Results - PHYS 4710/4711 Capstone Course**

#### **Results:**

Two physics majors took the PHYS 4711 course this year. Both met the minimal expectations. Thus the target for this goal was attained. However, the small number of students involved in these courses means we will have to wait several years to get the general picture.

#### **Attachments:**

### **Learning Outcome 4 - Oral Communication**

#### **Define Goal:**

Students graduating in physics will demonstrate the ability to communicate their understanding orally in a presentation format.

#### **Intended Outcomes / Objectives:**

Students will demonstrate their ability to effectively communicate their capstone Advanced Experimental Physics project (PHYS 4710 or PHYS 4711). The targeted outcome is that at least 75% of students should meet or exceed the minimum communication standards on the project rubric.

DRILL DOWN-----

RELATED ITEM LEVEL 1

### **Learning Outcome 4: Assessment - PHYS 4710/4711 Capstone Oral Comm.**

#### **Frequency of Assessment:**

When necessary for graduating seniors

#### **Rationale:**

All physics majors take a senior lab course, either PHYS 4710 (4 cr) or PHYS 4711 (2 cr). 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.

RELATED ITEM LEVEL 2

### **Learning Outcome 4: Results - PHYS 4710/4711 Capstone Oral Comm. Results:**

Two physics majors took either the PHYS 4710 or 4711 course this year, both were judged by the faculty to have made acceptable oral presentations

#### **Attachments:**

### **Learning Outcome 5 - Technological Tools**

#### **Define Goal:**

Students graduating in physics will have received an introduction to a range of common technological tools appropriate to physics and related disciplines.

#### **Intended Outcomes / Objectives:**

All graduating physics majors and alumni report being adequately prepared to use technological tools appropriate to physics and related disciplines in their employment or graduate studies.

DRILL DOWN-----

RELATED ITEM LEVEL 1

## **Learning Outcome 5: Assessment - Technological Tools**

### **Frequency of Assessment:**

As necessary for graduating seniors; Approximately every five years

### **Rationale:**

Exit Interview 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 experiences 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. These interviews explicitly address how well prepared each student feels for their next career step, including their preparation in the use of technological tools and development of research skills.

Because of the low number of physics graduates, the alumni 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.)

RELATED ITEM LEVEL 2

## **Learning Outcome 5: Result - Technological Tools**

### **Results:**

Exit Interview:

Unfortunately, due to the COVID-19 situation, it was not possible to conduct exit interviews with this year's three graduating seniors.

Alumni Survey:

Due to the low numbers of graduates we only conduct this survey every 5 years. The most recent survey was conducted last year, in conjunction with our program review. A full report is attached, but significant results are:

- Alumni continue to be highly satisfied with the program and the overall level of preparation they receive for their future careers.
- The standard of preparation in Classical Mechanics and Thermodynamics is consistently rated as somewhat weaker than that in other topics.
- Alumni continue to rate their undergraduate research experiences as extremely valuable.
- We need to closely monitor perceptions of preparation for collaboration/working in teams.

**Attachments:**

alum\_survey\_report\_2019.pdf

**Learning Outcome 6 - Career Preparation****Define Goal:**

The TTU physics program will give students sufficient preparation in content and skills/techniques to continue to graduate school or obtain suitable employment.

**Intended Outcomes / Objectives:**

All graduating seniors and alumni will agree that the program prepared them well to continue on to graduate school in physics (or a closely related discipline) or to enter immediate employment, whichever is relevant to their particular situation.

DRILL DOWN-----

RELATED ITEM LEVEL 1

**Learning Outcome 6: Assessment - Career Preparation****Frequency of Assessment:**

As necessary for graduating seniors; Approximately every five years

**Rationale:**

Exit Interview 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 experiences 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. These interviews explicitly address how well prepared each student feels for their next career step, including their preparation in the use of technological tools and development of research skills.

Because of the low number of physics graduates, the alumni 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.)

RELATED ITEM LEVEL 2

## **Learning Outcome 6: Results - Career Preparation**

### **Results:**

#### Exit Interview:

Unfortunately, due to the COVID-19 situation, it was not possible to conduct exit interviews with this year's three graduating seniors.

#### Alumni Surveys:

Due to the low numbers of graduates we only conduct this survey every 5 years. The most recent survey was conducted last year, in conjunction with our program review. A full report is attached, but significant results are:

- Alumni continue to be highly satisfied with the program and the overall level of preparation they receive for their future careers.
- The standard of preparation in Classical Mechanics and Thermodynamics is consistently rated as somewhat weaker than that in other topics.
- Alumni continue to rate their undergraduate research experiences as extremely valuable.
- We need to closely monitor perceptions of preparation for collaboration/working in teams.

### **Attachments:**

#### RELATED ITEM LEVEL 3

### **Change Related to Learning Outcome 6, Program Goal 1 - Exploring a Health Physics Option**

#### **Program Changes and Actions due to Results:**

Until recently the physics program at TTU has been mainly geared toward those who wanted to pursue their studies into graduate school, with little emphasis on preparation for other careers. (A few years ago we did develop Option II (Applied Physics) programs of study with emphases in different areas, but none of these were really oriented toward a specific career or societal need.) With this primary emphasis, the number of students majoring in physics seems to have stabilized well below the long term goal of 50. However, during the past year, through a newly established contact at Cookeville Regional Medical Center (CRMC), it has been brought to our attention that a program in Health Physics may offer an opportunity to help address a predicted shortage of practitioners in this field, as well as recruiting more students for the department. Preliminary discussions along this line were interrupted by the COVID-19 situation, but during the coming year we will assess as to whether it would be feasible to collaborate with CRMC to establish such a program. This will involve a needs assessment, development of a possible program of study, and plans for the development and delivery of any necessary new courses. As a first step, and to gauge interest among students already at TTU, we will offer a 'special topics' course in Introductory Health Physics, taught by our contact at CRMC.

**Link to Assessment:**

The number of physics majors at TTU seems to have stabilized at a five-year average of around 30 (Tool 1, Result 1). In order to try to grow this number (Program Goal 1) we continue to try various approaches to improve recruitment and retention. Therefore, one consideration in exploring the possibility of proposing a Health Physics program is the impact it may have on the number of majors. Eventually such a program would contribute to alumni perceptions of career preparation (Learning Outcome 6, Tool 8, Result 8).

**Learning Outcome 7 - Development of Research Skills****Define Goal:**

Students graduating in physics will demonstrate the skills and techniques needed to engage in planning and carrying out basic or applied research.

**Intended Outcomes / Objectives:**

Students will demonstrate competency by completing a research project in PHYS 4730 (Research Planning) and PHYS 4740 (Research) courses taken as seniors. Students will meet or exceed the minimum standards of the research course (PHYS 4730 or PHYS 47140). The targeted outcome is that at least 75% of students should meet or exceed the minimum standards.

DRILL DOWN-----

RELATED ITEM LEVEL 1

**Learning Outcome 7: Assessment - Research Involvement and Skills Development****Frequency of Assessment:**

End of each academic year

**Rationale:**

PHYS 4730 (Research Planning) and PHYS 4740 (Research) Capstone

All physics majors must take these two senior level research courses. To be successful in these courses students must create a detailed research plan and present it both in written and oral formats (PHYS 4730). They must then conduct the planned research and again present the results in written and oral formats (PHYS 4740). Each year the department will judge students' competence in planning and conducting research and communication.

## Student Research Involvement

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.)

## Exit Interviews

The department chair already conducts a confidential exit interview with each graduating physics major. These interviews explicitly address how well prepared each student feels for their next career step, including their preparation in the use of technological tools and development of research skills.

## RELATED ITEM LEVEL 2

### **Learning Outcome 7: Results - Research Involvement and Skills Development**

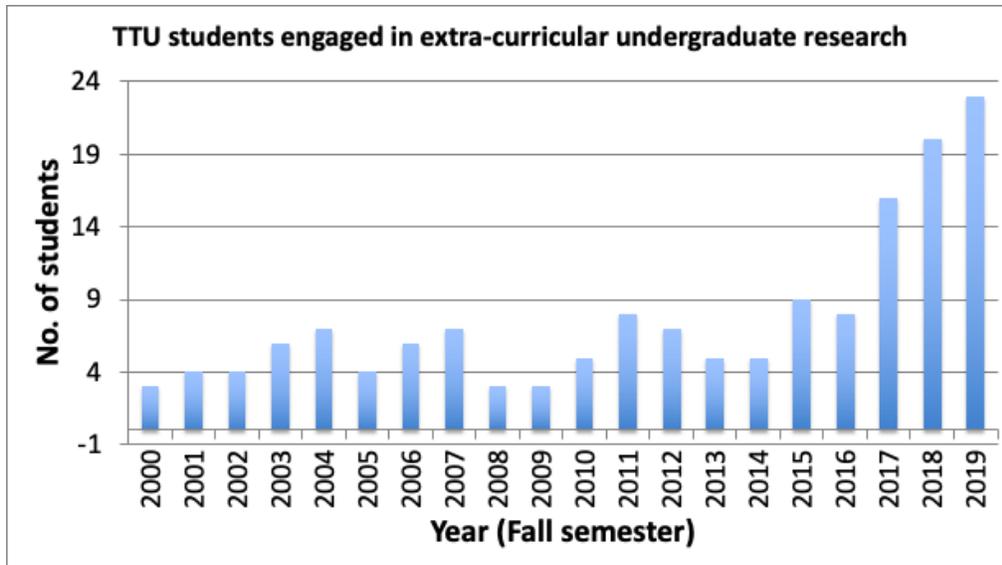
#### **Results:**

PHYS 4730 (Research Planning) and PHYS 4740 (Research) Capstone

Two students completed these courses this year and met the minimal standards for success, thus demonstrating their attainment of the required skills and in planning and carrying out research.

#### Student Research Involvement:

During this year a total of twenty-three individual undergraduate students participated in research activities of various types with department faculty members. In addition one graduate student in the College of Education was mentored by two physics faculty members. All physics majors who desired such an experience were accommodated, thus achieving the target for this goal.



#### Exit Interviews

Unfortunately, due to the COVID-19 situation, it was not possible to conduct exit interviews with this year's three graduating seniors.

#### Attachments:

### Program Goal 1 - Number of Physics Majors

#### Define Goal:

The Department will recruit and retain sufficient majors for a thriving educational program.

#### Intended Outcomes / Objectives:

Due to the low number of physics majors, a five-year average, calculated at the beginning of each fall semester, is used to track trends. The current target is that this average will increase by at least one per year. Having sustained an average of at least 30 majors for several years, the current minimum acceptable threshold is that the average number of majors should not drop below 30.

DRILL DOWN-----

RELATED ITEM LEVEL 1

### Program Goal 1: Assessment - Number of Physics Majors

#### Frequency of Assessment:

Beginning of every fall semester

**Rationale:**

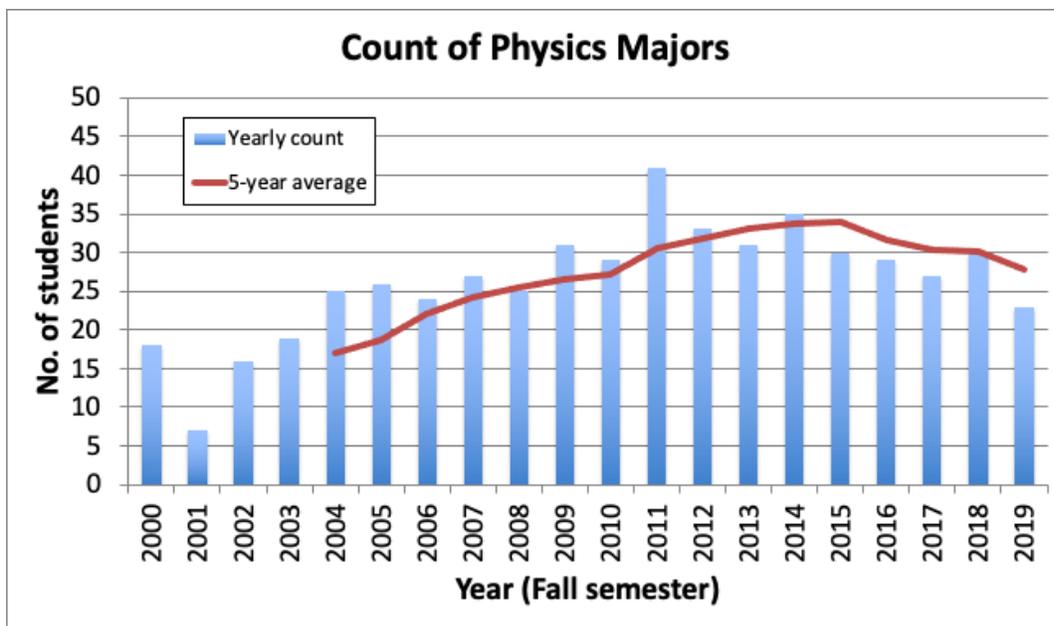
At the beginning of each fall semester a count is made of the number of the total number of enrolled students who have Physics declared as a major. Because of the small numbers involved, trends are tracked using an average of the current year plus the previous four years.

RELATED ITEM LEVEL 2

**Program Goal 1: Results 2 - Number of Physics Majors**

**Results:**

The number of declared physics majors at the start of the Fall 2019 semester was 23. This was an anomalously low number which nevertheless reduces the 5-year average to 28, below the minimum acceptable threshold. Thus, in the coming year, we are placing an increased emphasis on recruitment and retention, as discussed in another section of this report.



**Attachments:**

RELATED ITEM LEVEL 3

**Change related to Program Goal 1 - High School Speakers Program**

**Program Changes and Actions due to Results:**

In an effort to raise the profile of the department, as well as make direct contact with prospective physics majors, we will compile a list of high schools offering AP and Honors physics classes. We will then contact the instructors of these classes and offer faculty and student volunteers as visiting speakers who can give presentations on various topics, as well as advertise/recruit for our program.

**Link to Assessment:**

The number of physics majors at TTU seems to have stabilized at a five-year average of around 30 (Tool 1, Result 1). In order to try to grow this number (Program Goal 1) we continue to try various approaches to improve recruitment and retention. This speaker program is an attempt to recruit directly to those already taking a physics course in high school.

**Program Goal 2 - STEM Center Involvement**

**Define Goal:**

The Physics Department will contribute to the mission of the Millard Oakley Center for Teaching and Learning in Science, Technology, Engineering, and Mathematics (STEM).

**Intended Outcomes / Objectives:**

The target outcomes for this goal are twofold, involving physics faculty and students:

- i. The majority of faculty in the department will support the center by teaching at least one class using its facilities and/or facilitating activities in center outreach events.
- ii. Physics students will engage in at least three center outreach activities per year.

The minimum acceptable threshold is to maintain involvement via at least one faculty member and student engagement in at least one outreach event.

DRILL DOWN-----

RELATED ITEM LEVEL 1

**Program Goals 2: Assessment - STEM Center Involvement**

**Frequency of Assessment:**

End of each academic year

**Rationale:**

At the end of each academic year, a count is made of the number of actual or proposed projects, programs, and outreach events in which members of the Physics faculty and physics

undergraduates were jointly involved with the Millard Oakley Center for Teaching and Learning in Science, Technology, Engineering, and Mathematics (STEM).

#### RELATED ITEM LEVEL 2

### **Program Goal 2: Results - STEM Center Involvement**

#### **Results:**

Physics faculty involvement in projects and programs associated with the Millard Oakley STEM Center (MOSC) increased significantly due to the department being displaced while Bruner Hall is renovated. Four faculty members taught at least one course using the MOSC facilities. Two of these faculty members were also PIs on separate grants administered by MOSC and three were involved in four separate public outreach events offered by MOSC. In addition, several physics majors were involved in planning and facilitating 'stations' at two of these outreach events. This does not quite meet the target for involvement of students or faculty, but far exceeds the minimum acceptable.

#### **Attachments:**

### **Program Goal 3 - Improving Instruction**

#### **Define Goal:**

Ensure the use of effective and innovative pedagogical methods within the classroom.

#### **Intended Outcomes / Objectives:**

All faculty will report on changes/innovation in instruction in their annual reports, reflecting on their utility with regard to student learning and attitudes. Changes that result in improved student performance are expected to be adopted and will be shared with the department as a whole. As a minimum, faculty are expected to report on one such strategy per year.

#### DRILL DOWN-----

#### RELATED ITEM LEVEL 1

### **Program Goal 3: Assessment - Teaching Developments**

#### **Frequency of Assessment:**

annually

#### **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.

## RELATED ITEM LEVEL 2

### **Program Goal 3: Results - Teaching Developments**

#### **Results:**

Encouragingly, all faculty reported that they tried at least one different strategy in a class this year (though some of this was related to the COVID-induced transition to online delivery). However, not all reflected on the effect of their chosen strategy on student learning or attitudes.

Major developments in instruction that were reported included:

- Further adoption of the 'flipped' class format developed for the PHYS 2110 class.
- Offering of an online section of PHYS 2110 in the Fall, Spring, and Summer semesters.
  - Initial indications are that students in this section did not perform any worse than those in face-to-face sections.
- Development of an online version of PHYS 2120 that will be field tested by two faculty in the coming Fall semester.
- Refinement of the Frontiers of Physics freshman seminar class (PHYS 1173), taught for the second time.
- Initial offering of the Observational Astronomy (ASTR 3100) course in Fall 2019.

#### **Attachments:**

## RELATED ITEM LEVEL 3

### **Change related to Program Goal 3, Learning Outcomes 1 & 2 - Teaching Reflection**

#### **Program Changes and Actions due to Results:**

Over the past few years most department faculty have reformed their courses to incorporate some active-learning strategies, in some cases completely revamping the format to be much more student-centered. It is likely that this gradual shift in instructional modalities is responsible for the evident improvement in diagnostic test scores. However, in some cases, after introducing one or two such strategies nothing more has been tried for several years. In order to promote more reflection on their teaching, Program Goal 3 will be changed to state explicitly that faculty are expected to report on at least one NEW strategy per year."

#### **Link to Assessment:**

While faculty will reflect on the effectiveness of new strategies in their annual reports (Tool 4, Result 4), improvements in student learning and attitudes should also become apparent in the FCI diagnostic test (Tool 4, Result 4), Major Field Test (Tool 6, Result 6), and Exit Interviews (Tool 9, Result 9). Longer terms effects will be assessed using the Alumni Survey (Tool 8, Result 8), hopefully addressing some deficiencies in preparation reported in certain content areas.

## **Program Goal 4 - Undergraduate Research Experience**

### **Define Goal:**

All physics majors will have the opportunity to gain experience in authentic basic or applied research.

### **Intended Outcomes / Objectives:**

All faculty engaged in research in suitable fields will seek support to engage interested physics majors in their work. Opportunities at other institutions and in other fields will also be made known to physics majors. The targeted outcome is that all physics majors will have the opportunity to engage in such opportunities as many times as they wish during their TTU career. At a minimum, any interested student should engage in at least one such opportunity.

DRILL DOWN-----

RELATED ITEM LEVEL 1

### **Program Goal 4: Assessment - Undergraduate Research Experience**

#### **Frequency of Assessment:**

End of each academic year

#### **Rationale:**

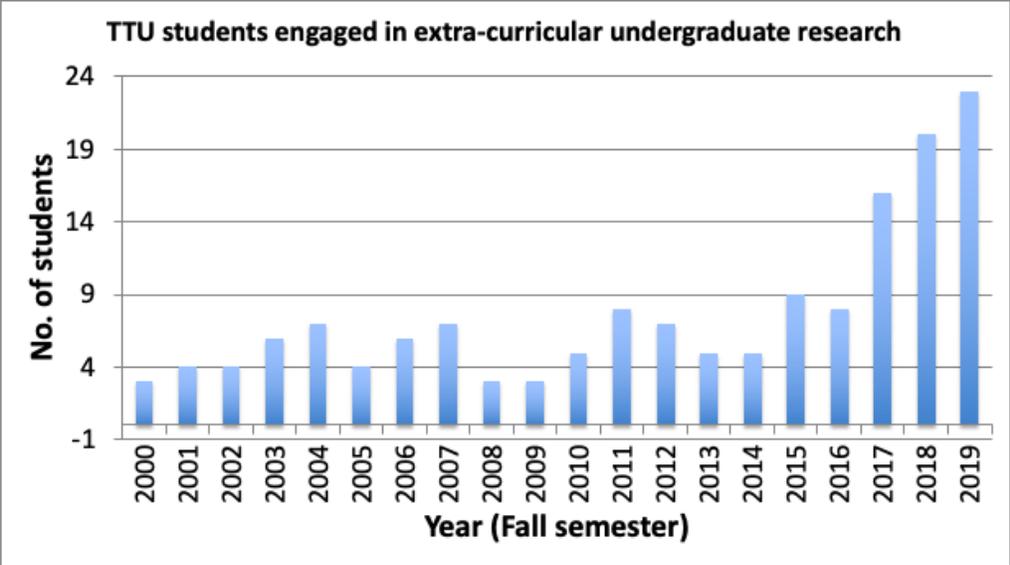
In their annual reports faculty members will be asked to report on any new pedagogical strategies they have tried, and reflect on their effectiveness.

RELATED ITEM LEVEL 2

### **Program Goal 4: Results - Undergraduate Research Involvement**

#### **Results:**

During this year a total of twenty-three individual undergraduate students participated in research activities of various types with department faculty members. In addition one graduate student in the College of Education was mentored by two physics faculty members. All physics majors who desired such an experience were accommodated, thus achieving the target for this goal.



**Attachments:**