

**University of Tennessee at Chattanooga**  
**Review of Physics Program and Major**  
**Review Cycle: 2011-2016**

**Prepared by**

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## Introduction

This report culminates a review that included a campus visit on March 8-10, 2017. The reviewer is Dr. Charles Bennett, Professor and Chair of Physics, University of North Carolina at Asheville.

The campus visit included interviews with members of campus administration, physics students, and all members of the UTC Physics Program.

## UTC Campus Overview

The UT Chattanooga (UTC) campus is a state supported institution of moderate size. According to the current UTC Factbook [1] there are just over nine thousand Full Time Equivalent (FTE) undergraduate students.

## Overview of the Physics Program and Major

The Physics Program at UT Chattanooga is housed within a combined department of Chemistry and Physics within the College of Arts and Sciences. There are five full-time Physics faculty and four of which are tenured. There are currently no full-time Physics faculty on tenure track. For comparison, there are currently thirteen full-time Chemistry faculty of which two are Lecturers. Over the past decade both programs have seen a general increase in the numbers of graduates: roughly 30-50 per year for Chemistry and 3-5 per year for Physics.

The relatively smaller number of graduates for the UTC Physics program is consistent with national trends. According to data collected and maintained by the American Institute of Physics, slightly more than half of the physics departments that award a bachelor's degree as their highest degree averaged 5 or fewer degrees per year [2]. Across the nation, the number of physics graduates per year at predominantly undergraduate institutions rarely exceeds the number of FTE physics faculty. The UTC Physics program outcomes are clearly consistent with national norms.

Focusing on the state of Tennessee, a recent list of physics graduates would include [3]:

<b>Institution</b>	<b>Undergraduate FTE</b>	<b>2015 Physics Graduates</b>
Austin Peay St. U.	7,900	11
ETSU	9,400	11
MTSU	19,600	13
Tennessee Tech	9,800	4
UT Chattanooga	9,200	6
UT Knoxville	24,400	15
Vanderbilt	6,900	11

Clearly, UTC physics statistics are right in line with its Tennessee neighbors.

Leadership for the Department of Chemistry and Physics is provided by Dr. Manuel Santiago. He is by all accounts a gifted administrator who approaches the challenges of a split department with fairness and equanimity. In none of my interactions at UTC did I ever detect the slightest hint of resentment or criticism of his administration. Everyone seems genuinely happy with his leadership. Associate Chair Dr. Tatiana Allen does an excellent job of representing specific program needs of Physics.

The departmental budget appears to be adequate to support needed instructional goals. Dr. Santiago appears to distribute these resources fairly and with attention to improvement.

Currently there appears to be sufficient space resources to support current instructional needs of the program. There is a grouping of three rooms with adjacent storage that support introductory laboratory instruction. Nearby smaller spaces support upper-level physics laboratory instruction. Each full-time physics faculty member has a small space in which to conduct research laboratory activities. All full-time physics faculty are encouraged to mentor undergraduate research projects, and all seem earnestly willing and eager to do so.

The UTC library has many resources to support research and professional development for physics faculty and students. The Center for Teaching and Learning is eager and capable to help faculty improve and enhance their teaching

## **Physics Program Goal**

As documented above, the UTC Physics Program maintains numbers of majors that compare well both regionally and nationally to other institutions of similar size. However, a long-term goal to double their graduation rate would increase the vitality of this program. Thus, the overarching program goal and major recommendation of the report is *to maintain the decade-long increase in physics graduates, and to increase these numbers even more in the future.*

## **Physics Program Challenges, Opportunities and Recommendations**

The following discussion is organized into sections each of which contains a major recommendation.

### **1. Increase Enrollments in PHYS 2300**

The UTC Clearpath four year plan for Physics [4] indicates that the typical entering student intending to major in Physics will not have their first physics course until first semester of their sophomore year; program recruitment efforts would undoubtedly be more successful if this first course could be taken in the freshman year.

Introductory Physics courses almost always accommodate a variety of disciplines; for example, a typical textbook for calculus-based physics have a title something like “University Physics for Scientists and Engineers.” The synergy that develops within a class of various STEM students is

palpable and exciting. Teaching introductory physics is fun precisely because of this diversity of interests.

Several decades ago a course was introduced within the Mechanical Engineering Department:

ENME 1030 - Basic Engineering Science

(3) Credit Hours

Introduction to basic concepts of engineering. Physical quantities, units, dimensions, vectors; formulation of engineering problems. Calculus-based analysis of fundamental dynamics; motion along a straight line and in a plane. Newton’s 1st, 2nd, and 3rd Laws of Motion plus applications. Work and energy. Impulse and momentum. Rotational motion. Fall and spring semesters. Lecture 3 hours. Prerequisite or corequisites: ENME 1030L or department head approval. Prerequisite or corequisites: MATH 1910 or MATH 1950 or department head approval. Differential Course Fee will be assessed.

Over time, ENME 1030 has replaced first semester Introductory Physics PHYS 2300 not only for mechanical engineers but also for engineering disciplines such as electrical engineering whose students go on to take the second semester of Introductory Physics PHYS 2310. This has two detrimental effects:

1. ENME 1030 is not an adequate preparation for PHYS 2310. Compared to first semester introductory physics, ENME 1030 is an abbreviated course, with a range of topics that fall short of even those covered in high school AP Physics C. It is no doubt a fine preparation for mechanical engineers, covering “what they need” and no more. However, the abbreviated topics covered by ENME 1030 does not adequately prepare students for the second introductory physics course PHYS 2310.
2. The resulting decreased enrollment in PHYS 2300 prevents it from being offered as often as it might be otherwise. This may account for why this course does not appear in the Physics Clearpath four year plan until the Fall of the sophomore year.

Data for the following table comes from the UTC Course Catalog and the AP Physics site [7]:

<b>Topic</b>	<b>ENME 1030</b>	<b>AP Physics C</b>	<b>PHYS 2300</b>
Kinematics	✓	✓	✓
Newton’s Laws	✓	✓	✓
Work, energy, power	✓	✓	✓
Linear momentum	✓	✓	✓
Circular motion and rotation	✓	✓	✓
Oscillations and gravitation		✓	✓
Heat and Thermodynamics			✓

There is much to admire about ENME 1030. Calculus 1 is a corequisite for this course, and necessary math concepts are integrated “Just In Time” within ENME 1030. It is a

recommendation of this review that a similar strategy be adopted for PHYS 2300; Calculus 1 should be changed from prerequisite to corequisite. In doing this, both engineering and science majors could take PHYS 2300 flexibly within the freshman year. Similarly, Calculus II should be a corequisite for Physics 2310.

Such changes will result in better prepared electrical engineers, and will bring better student success in PHYS 2310. Physics majors will get exposure to a physics course earlier in their career. It is a win-win change, but it is not a big change; UTC graduates about 30 electrical engineers per year [6]. Currently, PHYS 2300 enrollments are around 20 per year. Adding the electrical engineers will not necessitate additional sections of lecture. It is also the recommendation of this review that the ENME 1030 laboratory be cross-listed so that it also can satisfy the laboratory requirement for PHYS 2300. This will offer increased opportunity and flexibility for all STEM students, and will help insure curricular collaboration between Physics and Engineering.

ABET is agnostic with regard to this issue, although much has been written about how to best introduce basic physics into the engineering curriculum. See for example Reference [7].

Physics is currently developing a one SCH survey course designed to introduce prospective majors to career opportunities in Physics. This effort should be continued; it is another good way to get prospective physics majors into a physics course during their freshman year.

### **Recommendation**

Replace ENME 1030 Basic Engineering Science with PHYS 2300 Principles of Physics – Mechanics and Heat for all engineering student who go on to take PHYS 2310 Principles of Physics – Electricity and Magnetism. Currently, this would include all students in Electrical Engineering. Change the math pre and co-requisites of PHYS 2300 to match those of ENME 1030. Physics and Mechanical Engineering faculty should collaborate and coordinate the material in PHYS 2300 to assure that this course adequately serves the needs of the engineers. Finally, development should continue on a “First Year Experience” course that introduces potential physics majors of the opportunities associated with this career path.

## **2. Physics as a Gateway to Engineering**

There are many fields of engineering, not all of which are offered as degrees at UTC. Examples include aerospace, aeronautical, biomedical, nuclear, etc. A physics degree offers a firm bedrock of background that can be used to springboard off to graduate degrees in any field of engineering. Students are sometimes better able to decide what field of engineering to go into as a senior in college rather than a senior in high school.

### **Recommendation**

Include the option to major in Physics as preparation for advanced degrees in Engineering both in recruiting materials and on the program web page.

### **3. Continue to Develop the Biophysics Track**

Biophysics is a unique opportunity for UTC. Expertise to develop this track exists in current physics and chemistry faculty. The recent loss of a tenure-track physics faculty with expertise in biophysics should be replaced with a new tenure-track hire. The current search for a lecturer to fill this vacancy will provide a short term solution, but a tenure track hire will have more incentive to build the program and attract external funding.

Biophysics is not a common option in undergraduate physics programs. Once developed, students will come to UTC precisely because of this opportunity.

#### **Recommendation**

Continue to develop a track in Biophysics. The first step is to hire a new tenure-track biophysics faculty who can lead future development of this unique program.

### **4. Increase Support for Sigma Pi Sigma**

The UTC Physics program does a good job of supporting the Society of Physics Students, enhancing comradery among physics majors. The related Sigma Pi Sigma National Honor Society of Physics can identify and encourage physics majors with exceptionally accomplished scholarship and research.

#### **Recommendation**

Revive the UTC chapter of Sigma Pi Sigma. Develop induction criteria (e.g. 3.50 GPA in Physics) and hold induction ceremonies biannually or annually.

### **5. Contact Hours for Laboratory Instruction**

Teaching science laboratories is hard work with learning outcomes that cannot be achieved otherwise. UTC administration currently only credits science laboratory SCH's towards faculty teaching contact hours. This creates inequitable teaching loads for science faculty compared to disciplines that do not teach courses where the SCH is less than the actual hours invested in teaching.

The simple solution is to raise class size to the point where full-contact can be given for this important instruction at no cost to the University. For example, a faculty who teaches four three hour courses with 20 students in each course generates  $12 \times 20 = 240$  SCH's in a given semester. The same number of SCH's can be generated with a four hour class of 60 with three three-hour 20 student labs. Assuming availability of suitable classrooms, introductory science courses with enrollments of 60-100 are common at universities the size of UTC.

Another strategy might be achieved by increasing laboratory enrollments. For example, ten stations of two students each might increase to three students per station. This strategy will be more taxing for faculty; using student Teaching Assistants (TA's) might provide an effective solution.

The UTC Physics program includes recitation for some of its upper-level physics courses, which must currently be taught with the same SCH/contact hour penalty. Including a recitation for courses such as PHYS 3420 Electricity and Magnetism is not a universal approach (as is laboratory in introductory physics); simply teaching this as a four-hour lecture course might achieve the same scaffolding.

### **Recommendation.**

Physics should work with UTC administration to compromise on an approach that decreases the current inequity associated with laboratory instruction. Increasing class size is an obvious approach, as is increasing laboratory enrollments. As this compromise is reached, science department should examine current instructional strategies to insure that all faculty contact hours generated a similar instructional effort as teaching a lecture section.

### **6. Enhance Instructional and Outreach Activities Using the Clarence T. Jones Observatory**

This impressive facility is currently utilized for regular public viewing sessions. There is a vibrant collaboration with local astronomy amateurs via the local astronomy club. Jack Pitkin is dedicated in his support of this valuable campus resource.

### **Recommendation**

Improve the use of the Clarence T. Jones Observatory in both instruction and in undergraduate research. Some of the students interviewed in this review were very enthusiastic regarding a current research project that they had envisioned; similar research activities should be encouraged and supported. The possibility of an astronomy minor should be explored.

### **Summary of Major Recommendations**

The following recommendations have been made in the discussions above:

1. Replace ENME 1030 Basic Engineering Science with PHYS 2300 Principles of Physics – Mechanics and Heat for all engineering student who go on to take PHYS 2310 Principles of Physics – Electricity and Magnetism. Currently, this would include all students in Electrical Engineering. Change the math pre and co-requisites of PHYS 2300 to match those of ENME 1030. Physics and Mechanical Engineering faculty should collaborate and coordinate the material in PHYS 2300 to assure that this course adequately serves the needs of the engineers. Finally, development should continue on a “First Year Experience” course that introduces potential physics majors of the opportunities associated with this career path.

2. Include the option to major in Physics as preparation for advanced degrees in Engineering both in recruiting materials and on the program web page.
3. Continue to develop a track in Biophysics. The first step is to hire a new tenure-track biophysics faculty who can lead future development of this unique program.
4. Revive the UTC chapter of Sigma Pi Sigma. Develop induction criteria (e.g. 3.50 GPA in Physics) and hold induction ceremonies biannually or annually.
5. Physics should work with UTC administration to compromise on an approach that decreases the current inequity associated with laboratory instruction. Increasing class size is an obvious approach, as is increasing laboratory enrollments. As this compromise is reached, science department should examine current instructional strategies to insure that all faculty contact hours generated a similar instructional effort as teaching a lecture section.
6. Improve the use of the Clarence T. Jones Observatory in both instruction and in undergraduate research. Some of the students interviewed in this review were very enthusiastic regarding a current research project that they had envisioned; similar research activities should be encouraged and supported. The possibility of an astronomy minor should be explored.

## **THEC Program Review Checklist**

The following comments address specific items on the THEC Program Review Checklist. Some discussion points above are repeated here for clarity. Major recommendations of this review are itemized above; additional recommendations are contained in the comments below.

### **1. Learning Outcomes**

#### **1.1. Program and student learning outcomes are clearly identified and measurable.**

Physics majors at UTC compare well to students even at flagship R1 universities. Most if not all of them are involved with at least one undergraduate research project mentored by UTC physics faculty. Most of the students I talked to planned to pursue graduate studies after graduating from UTC.

I visited two classes and met with two groups of students during my visit. The students were truly remarkable; one group of six students was excited to tell me about a research project that they conceived using the available C.T. Jones Observatory. Faculty member Dr. Robert Marlowe has agreed to mentor them. Such self-motivation is priceless, and these students will undoubtedly find many opportunities to disseminate their research.

The Physics Department assesses student success using standard national and regional tests for physics majors. Learning outcomes for general education classes are assessed using pre and post tests using in-house instruments.

Established assessment instruments can provide useful feedback with data that can be compared nationally. For example, the Force Concept Inventory (<https://www.physport.org/assessments/assessment.cfm?A=FCI>) and Mechanics Baseline Test are very useful instruments for introductory first semester algebra and calculus based physics.

**1.2. The program uses appropriate evidence to evaluate achievement of program and student learning outcomes.**

Learning outcomes for upper-level instruction are measured by the *Rubrics* instrument consisting of constructed response questions. Outcomes goals are appropriate and in fact ambitious. Plans are to also assess undergraduate research and student presentations.

**1.3. The program makes use of information from its evaluation of program and student learning outcomes and uses the results for continuous improvement.**

The department is focused on the assessment outcomes to inform future improvement strategies.

**1.4. The program directly aligns with the institution's mission.**

All faculty and staff interviews are enthusiastic supports of UTC's Mission, Values, and Strategic Plan. Of particular note is the Chemistry/Physics support and encouragement of undergraduate research.

**2. Curriculum**

**2.1. The curriculum content and organization are reviewed regularly and results are used for curricular improvement.**

Course content is regularly assessed by faculty to better fit student demand and need. One opportunity for future growth is to further enhance the content of first semester calculus based physics to better articulate with the Engineering curriculum.

**Recommendation**

Adjust the course co-requisites and content of PHYS 2300 to facilitate the curricular needs of Electrical Engineering students. Details on the specifics of this recommendation

can be found above under Major Recommendations.

**2.2. The program has developed a process to ensure courses are offered regularly and that students can make timely progress towards their degree.**

This is a major challenge of the Physics program. Their major requirements consist of a core collection of courses and major electives that are Strongly Recommended. The elective courses are taught as needed for student matriculation. It can happen that such courses fall below minimum course requirements; in this case faculty must teach the course as independent study outside their normal course load. This can negatively affect time that could otherwise be devoted to undergraduate research, etc.

**Recommendation**

The department should settle on a more comprehensive set of core course requirements that can be offered on a regular (but possibly alternate year) schedule. This can help insure that all courses taught have adequate enrollment. Details on the specifics of this recommendation can be found above under Major Recommendations.

**2.3. The program incorporates appropriate pedagogical and/or technological innovations that enhance student learning into the curriculum.**

The faculty make effective use of online homework to facilitate introductory course instruction. University support of online tutoring resources provide essential support and scaffolding for introductory and general education students. The Walker Center for Teaching and Learning provides excellent support and faculty development opportunities for new and seasoned teachers.

**2.4. The curriculum is aligned with and contributes to mastery of program and student learning outcomes identified in 1.1.**

Undergraduate physics instruction follows a standard canon that facilitates assessment efforts and results that can be compared to national averages. Textbook and other instructional resources used at both the introductory and advanced levels are similar to those used at most other universities.

**2.5. The curricular content of the program reflects current standards, practices, and issues in the discipline.**

The curricular content of the Physics major curriculum does an outstanding job of preparing students for graduate studies.

**2.6. The curriculum fosters analytical and critical thinking and problem-solving.**

Physicists are problem solvers, and thus critical thinking is integral to the study of physics. Physics faculty are eager to support UTC SACSCOC Quality Enhancement Plan activities.

**2.7. The design of degree program specific courses provides students with a solid foundation.**

All upper-level instruction utilizes widely used and recognized textbooks. Coverage is comprehensive and provides an excellent preparation for graduate studies in Physics.

**2.8. The curriculum reflects a progressive challenge to students and that depth and rigor effectively prepares students for careers or advanced study.**

The Physics Clear Path four year plans are thoughtful and well planned. Students graduating in Physics are well prepared for graduate study in Physics and in any area of Engineering.

An undergraduate degree in Physics is excellent preparation for graduate study in any field of engineering. Students can better identify the field of engineering that is of most interest to them as seniors in college rather than seniors in high school. A physics degree provides a broad comprehensive bedrock upon which to build a career in engineering. This is a good marketing strategy to attract talented physics majors.

**2.9. The curriculum encourages the development of and the presentation of results and ideas effectively and clearly in both written and oral discourse.**

Undergraduate research is an integral part of the physics curriculum. Students regularly present their results at conferences. Physics faculty do an excellent job at taking students to conferences and at organizing field trips. Students actively seek opportunities with NSF-supported Research Experiences for Undergraduates (REU) campuses.

**2.10. The curriculum exposes students to discipline-specific research strategies from the program area.**

Almost every student I talked to was currently involved in at least one faculty-mentored undergraduate research project.

**3. Student Experience**

**3.1. The program provides students with opportunities to regularly evaluate the curriculum and faculty relative to the quality of their teaching effectiveness.**

Student rating of instruction are conducted via the internet, greatly facilitating this important feedback.

Recommendation: link early access of course grades to completion of the online teaching assessments to further enhance completion rates.

**3.2. The program ensures students are exposed to professional and career opportunities appropriate to the field.**

Physics faculty regularly conduct field trips and visits to local resources to expose students to real world activities and opportunities. Physics faculty take students to national labs such as Oak Ridge National Laboratory to conduct research. The Chemistry/Physics department does a great job at supports such activities.

Recommendation: look for opportunities to involve faculty at Erlanger Medical Center for talks and instruction, especially as the Biophysics program is developed.

**3.3. The program provides students with the opportunity to apply what they have learned to situations outside the classroom.**

The Chemistry/Physics department is enthusiastic in its support of undergraduate research. Physics students are active in seeking summer research opportunities at UTC and elsewhere.

**3.4. The program seeks to include diverse perspectives and experiences through curricular and extracurricular activities.**

The Chemistry/Physics department appears to be inclusive to all perspectives.

**3.5. Students have access to appropriate academic support services.**

Students have access to generous tutoring opportunities supported by UTC. This includes on-line tutoring resources.

**4. Faculty (Full-time and Part-time)**

**4.1. All faculty, full time and part-time, meet the high standards set by the program and expected SACSCOC guidelines for credentials.**

All UTC Physics faculty are energetic and sincerely interested in student success and opportunity.

**4.2. The faculty are adequate in number to meet the needs of the program with appropriate teaching loads.**

At the time of this interview, there was a faculty vacancy that is currently being advertised as a lecturer position. This should be filled as soon as practicable with a tenure-track position in Biophysics.

**4.3. The faculty strives to cultivate diversity with respect to gender, ethnicity, and academic background, as appropriate to the demographics of the discipline.**

UTC Physics faculty are committed to diversity in all aspects of instruction and research.

**4.4. The program uses an appropriate process to incorporate the faculty evaluation system to improve teaching, scholarly and creative activities, and service.**

Campus-wide student rating of instruction efforts are collected. The UTC Center for Teaching and Learning is available to review these results and aid faculty as they strive to improve instruction.

**4.5. The faculty engages in regular professional development that enhances their teaching, scholarship and practice.**

All UTC Physics faculty have research space available to conduct innovative research. Dr. Santiago deserves credit for his energetic support of undergraduate research. Nearby government research laboratories are utilized by faculty and students. Physics students regularly apply for NSF sponsored Research Experiences for Undergraduates opportunities.

**4.6. The faculty is actively engaged in planning, evaluation and improvement processes that measure and advance student success.**

Dr. Santiago is tireless in his efforts to combine support for the two departments (Chemistry and Physics) that he administers from available resources.

**5. Learning Resources**

**5.1. The program regularly evaluates its equipment and facilities, encouraging necessary improvements within the context of overall institutional resources.**

All introductory and upper-level instructional laboratories are well stocked. Staff member Jack Pitkin does an excellent job at organizing and maintaining these resources.

**5.2. The program has access to learning and information resources that are appropriate to support teaching and learning.**

The Walker Center for Teaching and Learning offers many resources for faculty interested in improving their teaching. Executive Director Dr. Dawn Ford provides effective administration. Personal note: as a past director of the UNC Asheville Center for Teaching and Learning, I especially enjoyed visiting the UTC facilities.

**6. Support**

**6.1. The program's operating budget is consistent with the needs of the program.**

The budget resources provided to the Chemistry/Physics Department are adequate to support instructional and research needs.

**6.2. The program has a history of enrollment and/or graduation rates sufficient to sustain high quality and cost-effectiveness.**

The number of Physics graduates has increased steadily over the past decade. The physics program graduates students in numbers that are comparable to cohort institutions.

**6.3. The program is responsive to local, state, regional, and national needs.**

UTC Institutional Research is committed to state imperatives such as that of this review activity. The UTC administration is committed to community engagement; the Clarence T. Jones Observatory is an especially valuable resources for local and regional community engagement.

**References**

1. <https://www.utc.edu/planning-evaluation-institutional-research/factbook/>
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