University of Tennessee at Chattanooga

Department of Chemistry and Physics

Six-Year Review Document 2011 – 2016

PHYSICS PROGRAM

PREFACE/HISTORY

The physics program serves our majors as well as students from the other three colleges. During the 2012 program review, the Department of Physics, Geology, and Astronomy offered two degree programs, General Education courses, and Astronomy classes. In 2014, the University of Tennessee at Chattanooga began a reallocation of resources that eventually lead to the merging of the chemistry and physics programs the following year to become the Department of Chemistry and Physics. The Geology program merged with the Biology department due to their environmental similarities. The merger of the chemistry and physics programs consolidated the duties of the department head and administrative assistant, the state operating budget, as well as the program personnel. The department operates on three floors with some research labs on the first floor.

The physics program offers a B.S. in Physics; B.S. in Physics: Biophysics, and a B.S. in Physics: STEM. On average, the program possesses 28 majors and graduates four (4) students per year. According to the American Institute of Physics in the September 2016 Survey, the physics program ranked second (2^{nd}) in the state of Tennessee for students enrolled in introductory physics courses. We ranked sixth (6^{th}) in graduating majors from among the other 15 state undergraduate institutions. The physics program also contributes to degrees in other sciences, engineering, and professional studies, by offering courses that relate to these other majors. The students from the College of Engineering and Computer Science, as well as from the Chemistry and Biology programs, are the highest percentage of students registering for physics courses. Because of its emphasis on natural science, students matriculate in physics courses for graduate and professional health programs requiring the Graduate Records Examination (GRE), Medical School Admissions Test (MCAT) and Dental Admissions Test (DAT).

The physics program is committed to providing students with the knowledge of physics and the intellectual skills necessary for them to succeed in graduate studies or professional endeavors and to be valuable members of our society. This abiding commitment is upheld irrespective of the organizational alignment of the program that merged with the chemistry program in 2015. Since the merger, the program experienced numerous adjustments and adaptations. In the first year, we developed a course offering scheme that would allow for program majors and students interested in taking physics courses to anticipate their offerings.

The revised academic semester schedule provided opportunities for students to matriculate for multiple courses that would allow them to progress through their program where otherwise they would have to wait for the course to be offered. Through mutual collaboration, the chemistry and physics programs have always worked closely with each other. The reallocation of resources due to the merger facilitated additional correspondence and coordination. Presently, the department houses over 30 members.

The off-campus UTC Clarence T. Jones Observatory provides astronomy presentations to the community at large. The observatory website may be accessed via the chemistry and physics website. The program also offers astronomy courses that is augmented by specialized equipment for astrophotography.

The last external review for the physics program was conducted in 2012. There were seven recommendations that the external reviewer highlighted. Because of the merger, the department will need to readdress these comments due to staffing and needs of other University programs. We are carefully analyzing the type of faculty discipline to hire and courses the program will be able to offer. The biophysics program was addressed from the previous review but the departure of the biophysicist created a void we are in the process of addressing with a new hire. Unfortunately, the assistant professor position will be staffed as a lecturer. The primary duties of a lecturer is to teach courses within the program. In the past, we have provided funds to a lecturer who had a desire to conduct research but it is not mandatory. Our focus is to hire a lecturer who has experience in biophysics. This person will teach the courses in the biophysics concentration.

Since the onset of the biophysics program in 2013, the department addressed a recommendation from the 2012 Program Review to consider biophysics as an interdisciplinary minor that accepts courses from biology, chemistry, and biophysics. The student will be able to select from Chemistry 4510 (Biochemistry) and/or Biology 4280 (Cellular Biology) as they progress through courses found in the physics program.

The department established goals to address teaching, research, and space allocation that would enhance the program in the years following the merger. This year faculty have been encouraged to attend research conferences with students to present project results. At present, faculty and students attended two conferences that demonstrate our commitment to supporting activities that attract students to our program. The new and developing website is advertising

past and current successes in the program, but more importantly student activities. We are also sending information to over 400 state high schools that mirrors the chemistry program's method of attracting prospective students to UTC.

The department is evaluating the operating budget in order to best support the merged departments and to maximize the use of funds to support travel, student workers, equipment, and research activities. Recently, the department used funds to purchase research equipment that would further enhance student engagement and publications. We have yet to venture across the campus to engage the engineering program regarding a joint faculty line that would augment the physics instruction in both departments. The College of Engineering and Computer Science hired a new dean whose aim is to increase faculty hires and increase research activities.

Both external and internal reviewers provided valuable input and recommendations during the previous program review. We have been able to accomplish many of the suggestions, which will be addressed more fully in succeeding sections. A few are highlighted below.

Accomplishments and Challenges:

1. The physics program successfully merged with the chemistry program creating the Department of Chemistry and Physics. The existing relationship with the chemistry department facilitated a smooth transition and collaboration.
2. The program continues to graduate and attract students to the program through local recruitments and through a campus open house that hosts students outside of this region. The department's statewide mailing initiative will expand our advertising range.
3. The revised course offering scheme should enhance student progression through the program. A consistent course offering will aid students when developing a schedule that enhances their success toward graduation.
4. The faculty are now allocated travel funds to present at research conferences. In addition, student travel funds have been budgeted to attend meetings that will expose them to current and future projects in their discipline.
5. The UTC Jones Observatory provides excellent linkage of the department to the community. It continues to offer opportunities for UTC students and local schools to experience a range of classes and use of the telescope.

6. We are pleased that all physics faculty members have individual research laboratories, and some undergraduate students are involved in their work. Also, faculty members take students to other universities and national laboratories to conduct research.
7. The student credit hour (SCH) production per faculty (excluding adjunct faculty) continues to be an aspect of faculty workload that needs further attention. Overall, from 2012 - 2014, the physics program experienced a 17% increase in fall SCH production. A reduction of 1% was identified in 2015, and this fall (2016) we had a decreased by 18%. Over a 5-year period, the five T/TT physics faculty averaged 405 and 416 SCH in the fall and spring, respectively. Current SCH production exceeds the 2014 Delaware Norm by 216% and 222%, respectively. With only having four T/TT faculty (3.75 FTEs), the total average SCH will be shared between the four faculty (610 in the fall and 659 in the spring), which would be 326% and 352%, respectively, over the Delaware Norm.

The level of preparedness of the students who matriculate in physics courses is varied both in their mathematical skills and physics backgrounds. Some are well prepared indeed. The department accommodates all students interested in physics. Our strengths and weakness will be described in the sections that follow.

1. **Learning Outcomes**

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

The Outcome Assessment is a campus wide program designed (a) to assess teaching quality and results, and (b) to fulfill the departmental evaluation requirements of the Southern Association of Colleges and Schools Commission on Colleges (SACSCOC). Our department started to engage in this program in 2004. Our objectives are:

1. Students completing the baccalaureate program in physics at UTC will compare favorably in their general knowledge of physics with respect to students that have completed similar programs.

2. Students completing the baccalaureate program in physics at UTC will compare favorably in their general knowledge of specific content areas with respect to students that have completed similar programs.

3. Students completing the baccalaureate program in physics at UTC will be satisfied with the education and training that they received.

To achieve these objectives, we have taken the following measures:

1. Arrange for graduating seniors to take a standard national or regional test, such as ACAT (Area Concentration Achievement Test) in physics or ETS (Educational Testing Service) in physics, administered by the Office of Planning, Evaluation and Institutional Research. We expect the students to perform up to the national average or better.

2. In order to obtain candid feedback from our students for future improvement of our teaching, the graduating students are asked to participate in an exit interview with the Head of the department and complete a questionnaire about his/her study experience at UTC.

In 2007-2008, the University adopted TaskStream, a web-based solution for performance assessment. In 2013, we replaced TaskStream with Compliance Assist to capture outcomes and assessment information.

Since the initial implementation of outcomes assessment in 2004, the results have shown that our teaching is effective. The scores of our graduates in the standard tests are comparable to the national or regional average. Our graduating students indicated satisfaction with the program on their exit questionnaires designed by physics faculty.

For General Education courses, a different method of outcome assessment was adopted. A pre-test is given at the beginning of the semester and a post-test is given at the end of the semester. We expect the students to score at least 50% better in the post-test as compared to the pre-test. In all the courses tested with this method, our students were performing better than the expectation.

1.2 <u>The program uses appropriate evidence to evaluate achievement of program and student learning outcomes.</u>

The methods for outcomes assessment described in the last section have some technical issues according to our past experiences. First, our graduates are usually few (as few as only one) and no meaningful statistics could be obtained from the standard test. The performance in the standard test was more a measure of the individual student(s) rather than that of our program. The adequacy of this standard test as an instrument of outcome assessment is then quite

questionable. Second, the exit interview and responses to the exit questionnaires tend to be subjective, instead of being an objectively measurable instrument.

Upon the recommendation of the Office of Planning, Evaluation and Institutional Research, the physics program phased out the standard test and the exit interview and questionnaires. Instead, we have adopted a new method of outcomes assessment; *Rubrics* began to be used starting in 2012.

The Rubrics is a matrix with a set of constructed-response questions (CREQ) instead of multiple choice questions. The type of questions asked will cause students to apply their knowledge, skills, and critical-thinking abilities to solve a hypothetical real-world problem appropriate to the subject matter and to explain their reasoning. The answer will be added to their overall efforts and it shall prepare them to tackle such questions in the future. Students are evaluated according to their responses to these constructed-response questions to be either exceeding expectation, meeting expectation or below expectation categories. Our goal is to have at least 67% of students exceeding or meeting the expectations. In this first year of implementation, three content core courses were chosen to be evaluated based on the Rubrics method: Physics 3410 (Classical Mechanics), Physics 3420 (Electricity and Magnetism) and Physics 4110 (Quantum Mechanics).

When the situation allows, we will try to apply the Rubrics method to the Physics Seminar (Physics 4000r) based on a student's performance in their research, oral presentation, or poster presentation.

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

The results of the outcome assessment are used to improve our teaching in many ways: 1) The assessment results are used to identify the areas that need reinforcement in teaching, and the instructions are adjusted accordingly; 2) The syllabi may be changed to reflect these needs; 3) If the issues are general enough to be addressed throughout the physics program, departmental meetings are called to discuss these issues and to plan the ways to address the issue.

The results of outcomes assessment are reviewed by the faculty to identify the areas of potential improvements in the following academic year, and plans are made to address the issues indicated by the rubric results.

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

Our program of outcomes assessment is designed and enacted in the purpose of achieving academic excellence by actively engaging students, faculty and staff; embracing diversity and inclusion; inspiring positive change; and enriching and sustaining our community. For example, in designing the questions in the rubrics, students, faculty and staff are involved to discuss the scope, depth and adequateness of the questions. Attention is paid to involve the minority and women students, who are also encouraged to participate and give presentations in the physics conferences. Their achievements in these activities are included as part of the outcome assessment. These are directly aligned with the mission of UTC.

2. **Curriculum**

In this section of the self-study, the major focus is on the available choices, sequencing, and scheduling of physics courses for the B.S. degree. In addition, we describe the general education courses offered by the department and show how they relate to other, more advanced courses. We next present the balance between the required and elective courses for the degree, followed by current approaches to teaching, opportunities for student research, and the development of appropriate student skills through their coursework. We then discuss the impact on the physics program of the Science, Technology, Engineering, and Mathematics (STEM) Education and Biophysics concentrations, which were not a part of the department when the previous self-study was completed in 2011. The section concludes with plans for updating the present curriculum, and thoughts on how the department can further assist our students in obtaining their desired education in order to prepare them for graduate school and/or the work force.

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

Students completing the B.S. in Physics at UTC have traditionally been prepared to enter graduate school, or enter the work force (often in a related area, e.g., computer programming, meteorology, electronics, nuclear power). About half of our graduates have opted for graduate

school; some past graduates of UTC over the last 10 years have pursued graduate degrees at the University of Alabama at Huntsville, Colorado State University, Yale Universtiy, and Virginia Commonwealth University in such areas as applied physics, astrophysics, and medical physics.

During the past decade, there has been a nationwide increase in undergraduate and graduate enrollments in physics and astronomy: for the academic year of 2004, there were approximately 5000 physics bachelor's degrees awarded by universities in the United States. By 2014, that number had grown to approximately 7500 (AIP Statistical Research Center). Our program also has seen a noticeable increase in majors over the past years: from spring 2005-spring 2006, our department averaged 14 physics majors (inclusive; see Appendix P-1). From fall 2010-fall 2011, the number increased to 25 majors. We anticipate that 8 majors will graduate during the next two years. We know that our graduates are able to enter into quality graduate schools without great difficulty, but many of them will choose to pursue areas other than pure physics. We believe that this will continue to be the case in the future.

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

2.2a *Choice*

The core courses (underlined hereafter in this section) of the physics curriculum are those traditional offerings which are absolutely necessary in order to pursue graduate work; a descriptive listing of these courses follows:

PHYS 2300/2300L: Introductory calculus-based mechanics with lab (3+1 hrs)
PHYS 2310/2310L: Introductory calculus-based electricity and magnetism with lab (3+1 hrs)
PHYS 2320/2320L: Introductory calculus-based optics and modern physics with lab (3+1 hrs)
PHYS 3410/3410L: Intermediate mechanics with recitation (4 hrs)
PHYS 3420/3420L: Intermediate electricity and magnetism with recitation (4 hrs)
PHYS 4110: Introductory quantum mechanics (3 hrs)
PHYS 3980: Methods of experimental physics I: classical experiments with lab (3 hrs)
PHYS 3990: Methods of experimental physics II: modern experiments with lab (3 hrs)

The advanced laboratory components (PHYS 3980 and 3990) of our curriculum were

created in their present format in 2006 as a result of suggestions made by an external reviewer in an earlier report. All other physics (and all astronomy) courses other than those named above are electives. The entire listing and descriptions for all department courses may be accessed at http://catalog.utc.edu/content.php?catoid=14&navoid=430. In the Chemistry and Physics Departmental website, links are available for all three physics degree programs: Physics, B.S; Physics: Biophysics, B.S.; and Physics: STEM Education, B.S. In order to focus the attention of our physics majors on those upper-level elective courses which are expected by graduate schools to be part of their background, the UTC catalog states under "Recommended Courses" for physics and/or astronomy:

Recommended: Physics 3030 (Basic Electronics), 3070 (Optics), 3110 (Introduction to Thermal Physics), 4120 (Nuclear Physics), and 4140r (Advanced Modern Physics) are recommended for students who plan on graduate study in physics/astronomy.

In particular, all students are counseled during their freshman orientation and academic year advisement sessions. They are shown how to access the "Clear Path" programs for their chosen majors, which lay out the recommended courses of study for each semester and detailing how they can obtain their chosen degree during a 4-year plan. The information they are introduced to can be found at http://www.utc.edu/advisement/advising-resources/clear-paths-for-advising/clear-paths-for-advising-2016-2017.php. This link directs them to webpages showing clear paths for physics, biophysics, and STEM education physics majors.

The following statement has been included in the current on-line chemistry and physics departmental description for those students desiring to teach physics (at the middle school/secondary level): "Students with a physics major that are also seeking licensure to teach physics should pursue their major through Physics: STEM Education, B.S."

In the past, the faculty believed that the omission of a physics course during the first semester of the freshman year has hurt our ability to attract well-qualified students. During the current semester (fall 2016), Dr. Joshua Hamblen taught PHYS 1999 Special Projects, a one (1) credit hour course designed to acquaint introductory students with some of the "hot" topics in physics today. This course will likely be offered again in the fall of 2017, giving us two years of experience to gauge its affect on attracting majors. We can then submit a proposal to the Curriculum Committee which would create a new course, Physics 1900 Introduction to Physics

(1 credit hour), specifically for the purpose of introducing freshmen and sophomore students to current areas of physics research.

We also discussed the establishment of a second new course, Physics 4100 Mathematical Methods for Scientists (3 credit hours), as a junior/senior level offering, which would be highly beneficial for those program majors interested in graduate work. Many university physics programs offer such a course to provide undergraduates with advanced mathematical techniques (e.g., Fourier and Laplace transforms, contour integration, selected partial differential equations, special functions) which are frequently encountered in theoretical physics. The instruction would emphasize the application of the techniques to physical problems. Such a course has been offered sporadically as PHYS 4140r Advanced Modern Physics. At the present time, we lack the faculty to offer such a course on a regular basis.

Certain elective courses (e.g., Physics 3040, 4190, 4240) have not been offered in recent history due to a lack of student demand for them; these courses have been dropped from the current UTC catalog in order to bring our course offerings up to date.

In the fall of 2010, a program known as UTeaChattanooga was instituted in the College of Arts and Sciences at UTC. It was designed to streamline the academic path of those majors in STEM areas who wish to teach at the middle or secondary school level. This program was an outgrowth of a proposal made by UTC to the UTeach Institute at the University of Texas (Austin). UTeaChattanooga has since been moved to the College of Education, where its name has been changed to STEM Education at UTC. The program has currently one new physics major (it had three physics majors prior to its move). Graduates of the STEM program will be true physics majors, in that they will complete all of the departmental core requirements. Upon graduation, these students will have the option of pursuing graduate work in physics or physics education, joining the workforce, or beginning a career as a licensed teacher.

Biophysics, a relatively new concentration for our department, began in 2013 under the leadership of Dr. Kristin Whitson of the physics faculty. Although she is no longer at UTC, the program remains intact, having the full support of the physics faculty and of our new department head, Dr. Manuel Santiago (Chemistry). Thus far, this program has graduated one student, who obtained a scholarship to the graduate program in biophysics at Yale University, where he is successfully pursuing a doctorate in biophysics.

2.2b, c *Sequencing and scheduling.*

Those physics, astronomy, and general science courses which are regularly taught are shown below (Table 2.2). "Every semester" is defined as the traditional fall and spring sessions. Courses and co-requisite laboratories are denoted by a slash (e.g., Physics 1030/1030L), and co-requisite recitations are so indicated (rec.). Courses approved as satisfying General Education requirements are preceded by the letter G.

Table 2.2

Course	2016-2017 Catalog Schedule
G-PHYS 1030/1030L Alg.-based Mechanics & Heat	every semester (also summer)
G- PHYS 1040/1040L Alg.-based E&M and Optics	every semester (also summer)
G- PHYS 2300/2300L Calc.-based Mechanics & Heat	fall semester
G-PHYS 2310/2310L Calc.-based E&M	every semester (also summer)
PHYS 2320/2320L Calc.-based Optics & Mod. Phys.	spring semester
PHYS 3030/3030L Basic Electronics	every 4th year in the spring
PHYS 3070/3070L Optics	fall semester alternate years
PHYS 3100/3100L (rec.) Intro. Thermal Physics	fall semester alternate years
PHYS 3410/3410L (rec.) Classical Mechanics	fall semester
PHYS 3420/3420L (rec.) Electricity and Magnetism	spring semester
PHYS 3980 Meth. Exp. Physics I	fall semester
PHYS 3990 Meth. Exp. Physics II	spring semester
PHYS 4000r Physics Seminar	fall semester alternate years
PHYS 4110 Intro. Quantum Mechanics	spring semester alternate years
PHYS 4140 Advanced Topics	every 4th year in the spring
PHYS 4120 Nuclear Physics	every 4th year in the spring
PHYS 4300/4300L Physics of Living Systems	on demand (required for Biophys.)
PHYS 4250 Computer based materials development	on demand
PHYS 4995 Departmental Thesis	on demand
PHYS 4998 Individual Studies	on demand
G-ASTR 1020/1020L Intro. to Astr. Stars-Galaxies	fall semester
G-ASTR 1010/1010L Intro. to Astr. Solar System	every semester
ASTR 4010 Solar System Astrophysics	every 4th year in the spring
G-GNSC 1110/1110L The Physical Environment	spring semester
G-GNSC 1150 Science and Society	fall semester

2.3 The program incorporates appropriate pedagogical and/or technological innovations that

enhance student learning into the curriculum.

The physics and astronomy curriculum presently contains eight introductory courses (six with co-requisite laboratories) which are recognized as General Education, i.e., each of these lecture/labs can be used to satisfy 3-4 hours of the university's natural science requirement. All of the associated lab courses involve computer technologies which introduce the student to data collection and analysis, especially through graphing. These courses are:

(1) General Science 1110 The Physical Environment: Atoms to Galaxies (3 hrs)
Co-requisite lab: General Science 1110 General Science Laboratory (1 hr)
(2) General Science 1150 Science and Society (3 hrs)
(3) Astronomy 1020 Introduction to Astronomy: Stars to Galaxies (3 hrs)
Co-requisite lab: Astronomy 1020L Astronomy Laboratory – Stars to Galaxies (1 hr)
(4) Astronomy 1010 Introduction to Astronomy: The Solar System (3 hrs)
Optional lab: Astronomy 1010L Astronomy Laboratory – The Solar System (1 hr)
(5) Physics 1030 General Physics - Mechanics and Heat (3 hrs)
Co-requisite lab: PHYS 1030L General Phys. Laboratory – Mechanics and Heat (1 hr)
(6) Physics 1040 General Physics – Electromagnetism and Optics (3 hrs)
Co-requisite lab: PHYS 1040L General Phys. Laboratory – Electromag. and Optics (1 hr)
(7) Physics 2300 Principles of Physics - Mechanics and Heat (3 hrs)
Co-requisite lab: PHYS 2300L Principles of Physics Lab – Mechanics and Heat (1 hr)
(8) Physics 2310 Principles of Physics – Electricity and Magnetism (3 hrs)
Co-requisite lab: PHYS 2310L Principles of Physics Lab – Electricity and Magnetism (1 hr)

2.3a *General Science 1110 The Physical Environment: Atoms to Galaxies*
(Co-requisite lab GNSC 1110L)

General Science 1110 requires the least in the way of mathematical prerequisites, and so is popular among non-science majors as a means of fulfilling their general education science requirement. In this role, it most often serves as a terminal course. This course presents selected topics from the fields of physics, astronomy, geology, and chemistry with an emphasis on how scientists attempt, through the use of the scientific method, to unify and explore our physical universe. The following list provides the majority of topics covered in GNSC 1110, along with the physics and astronomy courses which have direct connections to them:

GNSC 1110 Course Topic	Physics/Astronomy Related Course
Measurement	PHYS 1030, 2300; ASTR 1020
Motion	PHYS 1030, 2300, 3410, 3980, 3990; ASTR 4010
Force and Motion	PHYS 1030, 2300, 3410, 3980, 3990
Work and Energy	PHYS 1030, 1040, 2300, 2310, 2320, 3410, 3420, 3980, 3990
Temperature and Heat	PHYS 1030, 2300, 3100, 3980, 3990; ASTR 4010
Electricity and Magnetism	PHYS 1040, 2310, 2320, 3030, 3070, 3420, 3990; ASTR 4010
Nuclear Physics	PHYS 1040, 2320, 3180, 3990, 4110, 4120
The Periodic Table	PHYS 1040, 2320, 4110
The Solar System	ASTR 1010
The Universe	ASTR 1020

Not only the lecture topics, but also the GNSC 1110 lab activities emphasize the direct connection to physics concepts which provides the foundation for all sciences.

2.3b *Astronomy 1010 Intro. to Astronomy - The Solar System (optional lab ASTR 1010L)*
Astronomy 1020 Intro. to Astronomy - Stars to Galaxies (co-requisite lab ASTR 1020L)

The introductory astronomy courses 1010 and 1020 each provide students with a brief survey of the historical progress of the discipline, and an appreciation of the physical principles which astronomers use to gather and interpret information from space, leading to our current theories on solar system origin and evolution, and the nature of stars and the evolution of the universe, respectively. As in General Science, the laboratory experiments are divided between hands-on activities (e.g., learning how to set up and use a telescope, using triangulation to measure distance) and computer simulations in which students gather and analyze data. Either of these courses can serve as a prerequisite for the higher level astronomy laboratory Astronomy 3000r. Concepts introduced in ASTR 1010 and 1020 are met again in the physics courses shown below:

ASTR 1010 and 1020 Course Topic	Physics/Astronomy Related Course
Kepler's Laws	PHYS 1030, 2300, 3410; ASTR 3000r, 4010
Newton's Laws of Motion	PHYS 1030, 2300, 3410; ASTR 4010
Universal Gravitation	PHYS 1030, 2300, 3410, 3990
Nature of Electromagnetic Radiation	PHYS 1040, 2320, 3420, 3070, 3980, 3990
Diffraction	PHYS 1040, 2320, 3070
Planck Blackbody Distribution	PHYS 1040, 2320, 3070, 3100

Properties of Telescopes	PHYS 1040, 2320, 3070; ASTR 3000r
Conversion of Matter into Energy	PHYS 1040, 2320, 4120; ASTR 4010

2.3c *Physics 1030 General Physics – Mechanics and Heat (co-requisite lab PHYS 1030L)*

2.3d *Physics 2300 Principles of Physics - Mechanics and Heat (co-requisite lab PHYS 2300L)*

The basic physical concepts developed in algebra-based Physics 1030 and calculus-based Physics 2300 are essentially the same, and may be summarized as follows:
units of measurement, vectors, Newtonian dynamics and kinematics for both uniform linear and rotational motion, universal gravitation, the conservation principles, the physics of fluids, temperature and heat, the laws of thermodynamics, and mechanical vibrations and wave motion.

The difference in presentation of these two courses stems from the emphasis placed on the power and elegance of the calculus in Physics 2300, which lays the foundation of Newtonian physics for all higher-level courses. Rather than use a tabular format with these two courses, suffice it to say that vectors, Newtonian dynamics and the conservation principles, mechanical vibrations and wave motion, introduced in both Physics 1030 and 2300, are used in the majority of higher level courses, and are particularly important in the program's core courses:
Physics 2310 Principles of Physics - Electricity and Magnetism (w/ lab)
Physics 2320 Principles of Physics - Optics and Modern Physics (w/ lab)
Physics 3410 Classical Mechanics (w/ recitation)
Physics 3420 Electricity and Magnetism (w/ recitation)
Physics 3980, 3990 advanced laboratories
Physics 4110 Introduction to Quantum Mechanics

The thermodynamics topics contained in Physics 1030 and 2300 are met again, primarily in Physics 3110 Introduction to Thermal Physics, but also in the Physics 4140 Advanced Modern Physics when the selected topic is Condensed Matter Physics, and in the advanced astronomy course, ASTR 4010 Solar System Astrophysics. (These latter low enrollment, upper level courses are now scheduled to be offered every fourth academic year). Reference to the 2016-2017 UTC Undergraduate Catalog finds that Physics 1030 and/or Physics 2300 are listed, either directly or indirectly, as a prerequisite for 22 higher level physics courses.

2.3e *Physics 1040 General Physics – Electromagnetism and Optics (co-requisite lab PHYS 1040L)*

2.3f *Physics 2310 Principles of Physics – Electricity and Magnetism (co-requisite lab PHYS 2310L)*

Physics 1040 provides an algebra-based survey of basic principles governing simple DC and AC circuitry, magnetism, and electromagnetic induction. The course then moves to geometrical and physical optics, and optical instruments and the structure of the eye. Finally, modern physics is introduced, emphasizing basic principles of special relativity, quantum and nuclear physics. It is particularly in the arena of modern physics that historical changes which physics brought to the world via new technologies are stressed. Physics 2310 is the calculus-based counterpart to the electromagnetic part of Physics 1040. Of the three 2000-level courses required for the physics major, it is generally considered to be the most difficult because of the mathematics involved. The culmination of the course is the presentation of Maxwell's equations. The two respective laboratory courses cover many of the same experiments, several of them being computer-assisted. The Physics 2310L lab has a greater emphasis on error analysis.

Reference to the 2016-2017 UTC Undergraduate Catalog finds that Physics 1040 and/or Physics 2310 appear, either directly or indirectly, in the prerequisites listings for at least 18 higher level physics courses. Like the PHYS 1030 and 2300 surveys of mechanics and heat, these survey courses of electricity and magnetism (and modern physics for PHYS 1040) are indispensable for more advanced undergraduate study. Core courses and regularly offered electives which require the principles first enunciated in either PHYS 1040 or 2310 include:

Physics 3030 Basic Electronics (w/ lab)
Physics 3070 Optics (w/ lab)
Physics 3410 Classical Mechanics (w/recitation)
Physics 3420 Electricity and Magnetism (w/recitation)
Physics 3980, 3990 advanced laboratories
Physics 4110 Introduction to Quantum Mechanics

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

A listing of the required courses (showing any co-requisite laboratory or recitation) for the B.S. in Physics, as found in the 2016-17 UTC Catalog, is presented below:

Title	Lab or Recitation	Total Credit Hrs.
PHYS 2300*Principles of Physics – Mechanics and Heat	L	4
PHYS 2310 Principles of Physics - Electricity and Magnetism	L	4
PHYS 2320 Principles of Physics - Optics and Modern Physics	L	4
PHYS 3410 Classical Mechanics	R	4
PHYS 3420 Electricity and Magnetism	R	4
PHYS 4110 Introduction to Quantum Mechanics		3

In addition, the following two advanced lecture-labs are core course requirements:

PHYS 3980 Methods of Experimental Physics I	L	3
PHYS 3990 Methods of Experimental Physics II	L	3

*Physics 1030 and 1040 may together be substituted for Physics 2300.

The required courses account for 29 credit hours. The 3000 and 4000 level required courses shown above do not count towards the B.S. degree requirement of

(a) "27 additional hours from physics, astronomy, chemistry, engineering, or mathematics at the 2000 level or above or from geology and biology or other fields with prior approval of the department."

However, these 3000-4000 level courses do count towards the minimum of 30 hours as stated in

(b) "Minimum of 39 hours of 3000 and 4000 level courses, which includes a minimum of 30 hours in physics and/or astronomy at the 3000 and 4000 level." (UTC 2016-17 Undergraduate Catalog: http://catalog.utc.edu/preview_program.php?catoid=16&poid=2527&returnto=527)

Physics and astronomy elective courses often comprise the bulk of requirement (a), in part because these electives are all 3000 and 4000 level courses, which have the effect of satisfying both requirements (a) and (b) simultaneously. In the case where a student would choose all courses for requirement (a) as coming from our program, one finds that the credit hour ratio of required courses to elective courses would be 29:30 – essentially half of the physics coursework for the B.S. would come from required courses. *This ensures that there is a good balance between courses inside and outside the major.*

The following electives are highly recommended for those wishing to pursue graduate study in physics or astronomy:

PHYS 3030 Basic Electronics (4)
PHYS 3070 Optics (4)
PHYS 3100 Introduction to Thermal Physics (4)
PHYS 4120 Nuclear Physics (3)
PHYS 4140r Advanced Modern Physics (3)

The faculty believe that these electives will provide an entering graduate student with a strong background for either experimental or theoretical work. Some examples of offerings of upper level elective courses are:

ASTR 4010 Solar System Astrophysics (fall 2012)
PHYS 3030/3030L Basic Electronics (spring 2014, spring 2016)
PHYS 3070/3070L Optics (fall 2015)

PHYS 3110/3110(rec) Thermal Physics (fall 2014, fall 2016)
PHYS 4140r Advanced Modern Physics (Mathematical Physics in spring 2015)
PHYS 4300 Physics of Living Systems (spring 2015).
PHYS 4120 Nuclear Physics (spring 2012)

Students wishing to enter the job market immediately after graduation are encouraged to confer with faculty as to their best choices for electives. Please see sections 2.9 and 2.10 for upcoming changes which will affect the overall program curriculum offerings.

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

Coursework at the 3000- and 4000-level often provides opportunities for faculty to give more in-depth analyses not only on their own research, but also on currently "hot" topics. The (elective) course, Physics 4000r Physics Seminar, allows students to explore, by giving oral and written reports of research/review articles in appropriate journals and periodicals, those areas which are of current interest to the physics community, as well as topics which they themselves find exciting. The Internet is a primary means to gather information about current events in science, and students are encouraged in this course to access information from respected and reliable sources (e.g., Scientific American, Physics Today, American Scientist (Sigma Xi)).

At the introductory level, Astronomy 1020 never fails to raise questions concerning the nature and veracity of our knowledge when students encounter the chapters entitled "Cosmology: The Big Bang and the Fate of the Universe," and "Life in the Universe: Are We Alone?" Instruction emphasizes the use of experimental evidence as the ultimate arbiter of theory, not only in astronomy but also in the introductory physics and general science courses.

The exposure of physics majors to "methods of inquiry commonly used in the field" is found throughout the curriculum, but for the most part is concentrated in upper level laboratory activities and independent research. For example, students are exposed to a variety of apparatus (e.g., amplifiers, delay lines, counters for radiation dosimetry and x-ray scattering) in Physics 3990 Methods of Experimental Physics II. In Physics 3030 Basic Electronics, digital oscilloscope techniques are encountered, as well as analog and digital electronics. Demonstration helium-neon lasers are used for holography by students in Physics 3070 Optics, as well as for other experiments in the advanced laboratory courses. Physics faculty members also instruct students in the use of medium grade telescopes. In the ASTR 3000r Advanced Astronomy Laboratory, a CCD (charge-coupled device) camera has been used for astrophotography, along with image-processing software.

At the 1000- and 2000-level, students gain some initial familiarity with interferometers, diffraction gratings, lasers, lenses, oscilloscopes, digital multimeters, radiation counters, and multichannel analyzers, all of which are commonly used to obtain data about the physical environment.

We have begun to upgrade both our more advanced and introductory physics laboratories through the use of computer-assisted data taking and data analysis.

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

Both the physics and astronomy curricula make provisions for faculty-supervised student research. Common to each are the 1990r Special Projects courses for 1000- or 2000-level research projects, and the 4998r Individual Studies and 4997r Research for more advanced projects. All courses specifically set for student research are of variable credit (1-9 hours). In addition, the physics curriculum provides for 4995r Departmental Thesis (1-3 hrs).

Majors are encouraged to participate in collaborative research with faculty, to attend scientific meetings at both the state and regional level, and to present papers or talks at scientific meetings. In November 2016, four UTC physics majors, accompanied by a faculty member, attended the meeting of the Southeastern Section of the American Physical Society (SESAPS) at the University of Virginia (Charlottesville, VA) where two presentations/poster sessions were made. Their attendance was funded by the department, college, and University.

Grants have been obtained by the faculty for the purpose of providing students with summer stipends, allowing them to engage in collaborative research. Students can design a research project under faculty supervision, and submit a proposal for a Provost Student Research Award to the Faculty Research Committee.

In addition, summer research programs, which are available at other universities or national laboratories (e.g., the NSF Research Experience for Undergraduates (REU) program), are beginning to be seen by students as an important step in getting a valuable headstart in pursuing research goals.

One item which has been lacking in our research program is the presence of a regular colloquium series, which would allow physicists and astronomers from nearby institutions to present an hourly talk on their research. The department needs to institute a semi-regular program of colloquia. Equally important, the department needs to provide field trips (preferably each semester) for its majors to visit physics and astronomy departments in nearby universities.

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

Written language skills are fostered throughout the physics curriculum at all levels through the students' preparation of laboratory reports.

In Astronomy 1020, most homework questions are designed to be answered descriptively, rather than through problem solving. Students in ASTR 1020 are requested to prepare their homework using word processing software.

In Physics 3070 Optics, students are typically required to present two written summaries of articles from a periodical such as Scientific American.

The course which may provide the most practice in both written and oral communication skills is PHYS 4000r Physics Seminar (most recently offered in fall 2016), in which students prepare both oral and written summaries of articles from journals such as *Physics Today* and *Scientific American.*

Computer literacy skills receive attention in both introductory and upper level courses: the department has 30 personal computer (PC) workstations for use in introductory courses. In addition to these, upper level students have two (2) additional computers containing more advanced software packages.

Mathematics skills required for the B.S. in Physics consist of the following 17 credit hours as a minimum:

Mathematics 1910/1911 Calculus I with Lab (4)
Mathematics 1920/1921 Calculus II with Lab (4)
Mathematics 2200 Elementary Linear Algebra (3)
Mathematics 2450 Introduction to Differential and Difference Equations (3)
Mathematics 2550 Multivariable Calculus (3)

Homework assignments and exams for the overwhelming majority of physics courses consist of setting up and mathematically solving problems. Those students who are not physics majors encounter problem-solving in the introductory level courses which are appropriate for the specified math prerequisites.

Critical thinking skills are developed throughout the curriculum to the extent that "problem solving" can be viewed as a subset of "critical thinking." Students may be asked to "chalk-talk" their solutions to the rest of the class, explaining their reasoning as they proceed through the solution.

Physics majors are encouraged to learn a high-level programming language (e.g., C++, Basic, or Python) since such knowledge is now considered a necessity in order to pursue research. As mentioned, computers are now being used in the 2000-level and higher laboratories for the procurement and analysis of data in several experiments. The department is continuing to apply this technology to more experiments in courses at all levels.

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

On several occasions during the past five years, the department has provided internships ($3,000) for physics majors to pursue summer research with a UTC faculty member: (a) two physics majors spent much of the summer at Oak Ridge National Laboratory as particle physics research assistants in experimental work under the direction of Dr. Joshua Hamblen. Other summer efforts occurring here at UTC have included majors (b) working with Dr. Robert Marlowe arranging an experimental layout in a dynamic light scattering lab; (c) performing low-temperature conductivity experiments with Dr. Tatiana Allen; (d) working on a departmental honors project with biophysicist Dr. Kristin Whitson, and (e) conducting literature searches in cosmology with Dr. Ling-Jun Wang. The department has sought to provide opportunities for non-physics majors interested in astronomy by employing them as assistants at the UTC Jones Observatory.

Another possibility for students getting practical job experience should be investigated with the UTC Challenger Center. The department should seek to assist those students interested in science teaching to develop projects (e.g., science demonstrations) with both the Challenger Center and the Chattanooga Creative Discovery Museum.

One of our majors has twice been awarded a Noyce Fellowship for students who are pursuing teaching in the STEM disciplines. Some of this money will be used to support students in summer research.

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

At the end of the academic year 2015-16, our department underwent a major administrative change, in that the Department of Physics, Geology, and Astronomy was dissolved. Physics and astronomy were recombined with chemistry to become the Department of Chemistry and Physics, while geology was combined with biology and environmental science to become the Department of Biology, Geology, and Environmental Science. We have also lost a full time tenure-track faculty member, who is to be replaced by a lecturer position in the fall of 2017. Since these changes have occurred, it is perhaps not surprising that some curricular changes have been instituted. Physics has, within the last year, begun to revise its curriculum in these ways:

(a) the faculty have decided to offer four of the upper level advanced elective courses (PHYS

3030 (Basic Electronics), 4120 (Nuclear Physics), 4140 (Advanced Topics), and ASTR 4010 (Solar System Astrophysics) as courses which alternate in a 4-year interval. This should allow faculty time to be used more efficiently, reduce the number of low-enrollment upper level courses, and relieve physics majors of scheduling pressures. The offering of these junior/senior level elective courses on a more regular schedule (other than "on demand") should enhance student opportunities for research, which develops their abilities for effective communication.

(b) because our number of student majors has increased since our last departmental review, we have decided to offer the PHYS 4000r Physics Seminar on a more regular basis.

(c) as aforementioned, the STEM Education program, which streamlines the path for majors in the STEM disciplines to teach, has had what can be described as a very encouraging impact on the physics program. We are committed to the process of helping bring science and math (and physics in particular) to high school students through the professional development of new teachers who are fully qualified with B.S. degrees in physics.

(d) new computers (36) were purchased during the academic year 2010-11 for exclusive use in all physics, astronomy, and general science lower level instructional laboratories. New laboratory instrumentation and software from Vernier has been installed for these computers, and has been used successfully during this same time frame. It should be reemphasized that in July 2008, extensive physical renovations to Grote Hall were undertaken, requiring that both our department and the Department of Chemistry to relocate the programs in other buildings. Our department was moved to the Engineering, Mathematics, and Computer Science building (EMCS) for two years, and moved back into Grote Hall during September 2010. During this period of time in EMCS, it is fair to say that we were concentrating more on the day-to-day regimen of meeting classes and surviving as a department, rather than working on curricular updates.

2.10 <u>The curriculum exposes students to discipline-specific research strategies from the program area.</u>

The department seeks to provide its majors with:

- a solid undergraduate background in classical and modern physics;
- an appreciation of -- and the ability to explain -- the importance of physics in other sciences and in technology;
- a capacity to critically evaluate scientific approaches in answering questions concerning the physical universe; and

• the ability to carry out, at an appropriate level, investigative research using current technology.

A student who minors in physics should be:
• knowledgeable in the discipline at the level of a secondary school instructor;
• able to describe the impact of physics on our culture and history; and
• able to successfully integrate the concepts of physics with those of his/her major field of study.

In order to bring these goals to fruition, the program must continue to update and strengthen its curriculum. This may best be accomplished through planned new courses, continued improvements in course scheduling, and new programs in tune with the needs of the recent job market (e.g., teaching careers).

We must offer more opportunities for student research with the present faculty, and through summer programs with other institutions and national laboratories.

More attention must be given to the students' ability to communicate, both verbally and in writing, clearly and concisely.

In particular, faculty must devote more time to mentoring students, i.e., helping them to explore not only the information of physics textbooks and the laboratory activities of "doing physics," but also the real world where physics is a profession.

3. **Student Experience**

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

The University conducts student ratings of faculty for all classes every semester. Each student has the opportunity to submit an evaluation for an instructor of a given class in a standard ratings form submitted online. In addition, students can provide specific, written feedback in the evaluation. Results of the student evaluations and any written feedback are available to the instructors at the end of every semester, once grades have been submitted. Instructors are able to use the feedback to make any changes to their instruction if necessary.

The ratings also factor in to a faculty member's annual performance evaluation during the Faculty Evaluation and Development by Objectives (EDO) process with the department head. The department head and dean of the College of Arts and Sciences have access to all faculty rating information.

The physics majors in our program are also able to provide feedback about the curriculum. Given the size of our program and the informal, friendly relationships with the

physics students, the students are in a unique position to request that certain upper-level physics and astronomy electives be offered in an upcoming semester if there is enough interest and it fits into the course schedule. We make every effort to accommodate student requests of this kind since it shows that students are taking an active role in their education.

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

Students are made aware of and encouraged to participate in all applicable conferences, research programs, and job opportunities. For example, students are encouraged to apply for summer research programs such as the Research Experience for Undergraduates (REU) and the Scientific Undergraduate Laboratory Internships (SULI) programs. Students are also encouraged to attend regional and national meetings such as the Southeastern section meeting of the American Physical Society (SESAPS) or the American Association of Physics Teachers (AAPT) annual meeting. Information about these programs is posted in the Physics Students group on the UTC Learn website as well as emailed to the students. Information about these programs is also posted on the bulletin board just outside the physics faculty offices and is kept updated.

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

Students apply their knowledge outside of the classroom in a number of different ways. They are encouraged to participate in independent research, either with the summer research programs mentioned in the previous section, or with faculty here at UTC. Students have many options in which to conduct research at UTC. The most often utilized method is by performing research with a faculty member by enrolling in PHYS 4997 Research. Students can also seek funding for summer research at UTC by applying for the physics program's Summer Research Scholarship. Another option for students is to develop a research project and gain funding by applying for UTC's Provost Student Research Awards program. In the last year, students from our local chapter of the Society of Physics Students (SPS) have developed their own research project in studying the most efficient striking methods attributed to personal self-defense. After a research project is complete, students are encouraged to present their research at an appropriate regional or national conference, in addition to presenting at UTC's Research Day program.

In addition to research, physics students volunteer and work at UTC's Clarence T. Jones Observatory as part of our outreach program. The students assist with a weekly observatory show during the academic year that is free and open to the public. Students also assist with the deep-sky viewing program that occurs once a semester in accordance with the introductory astronomy courses.

UTC's Walker Center for Teaching and Learning provides a ThinkAchieve grant program for faculty to incorporate experiential and beyond-the-classroom learning activities into their courses. In Spring 2016, Drs. Hamblen and Welch used a ThinkAchieve grant in their PHYS 3990 Methods of Experimental Physics II class to allow students to design and build their own radiation and cosmic ray detector from readily available parts.

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

As mentioned above, students are encouraged to participate in summer research programs at universities and laboratories around the country. The female physics majors are also encouraged every year to attend the annual Conference on Undergraduate Women in Physics hosted by the American Physical Society. The physics students run their own chapter of the Society of Physics Students and host many outreach events throughout the year (Table 3.4).

Table 3.4. Physics Program Outreach Events

Examples of Outreach Events	
October 21, 2015	Telescope demonstration at Chattanooga Girls Leadership Academy
November 17, 2015	Telescope demonstration at Girls Preparatory School
February 17, 2016	Hosted Nuclear Talks with four guest speakers
March 11, 2016	Took PHYS 2320 class to Tellus Science Museum
June 23, July 11, July 21, July 28, 2016	Freshman Orientation Fair 2016
August 22, 2016	Organizational Fair for entire student body
September 2, 2016	Greek Row Organizational Fair
September 10, 2016	Assisted at the Star Walk in Harrison Bay

The physics faculty come from diverse backgrounds and each has his/her own unique field of research expertise. This allows our students to be exposed to many different scientific perspectives. Accordingly, students are offered a wide range of physics courses, such as Optics, Nuclear Physics, Relativity, Computational Physics, Biophysics, and Astrophysics.

The physics program also brings in outside speakers to present talks that are open to the entire university in order to provide diverse perspectives. The program hosted a talk by NASA's Kepler project manager, Roger Hunter, in the spring of 2012. Dr. Wang also gave a seminar in the spring 2012 semester entitled "The Other Side of the Big Bang Theory" that was open to the public. During the spring 2016 semester, our Society of Physics Students hosted a series of talks centered on nuclear physics and engineering, which featured speakers from the US Navy, the Tennessee Valley Authority, and our own Drs. Hamblen and Waldecker.

3.5 Students have access to appropriate academic support services.

The University has a number of services dedicated to ensuring the academic success of students. The Counseling and Personal Development Center at UTC offers individual and group counseling that covers a wide range of issues such as dealing with the adjustment to college life, stress, anxiety, time management, substance abuse, and study skills. The Center for College and Student Success provides free tutoring in a number of popular introductory classes in physics, chemistry, mathematics, and other departments. The Center also provides supplemental instruction (SI) sessions for these courses that are run by upper level students (often physics majors) who answer questions and work with students who are seeking extra help in their large lecture classes. In addition, the Center provides a number of resources on note-taking, reading tips, exam preparation, and other skills necessary for academic success.

Our department works closely with UTC's Disability Resource Center to provide all students with disabilities the necessary accommodations to be successful in class. These services include note takers in class, testing with extra time in a distraction-free environment, and transcription of class materials such as audio or video.

The physics faculty also work individually with physics majors and other students in order to ensure their success. The faculty host regular office hours and post their teaching schedules outside their office doors in order to show their availability to students. Students are always encouraged to make use of the scheduled office hours for help in class and also schedule

an appointment outside of office hours if necessary. Each physics major is assigned an academic advisor from the physics faculty, and the student and advisor meet at least once a semester to make sure they are successful in their courses and progressing towards graduation.

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.

During 2011-2014, the physics program was a part of The Department of Physics, Geology, and Astronomy under leadership of Dr. Habte Churnet (geologist). Starting in the fall of 2014, the physics program merged with the Department of Chemistry, forming the Department of Chemistry and Physics under the leadership of Dr. Tom Rybolt (fall 2015- spring 2016) and Dr. Manuel Santiago (fall 2016 – current), both chemists. In the fall of 2015, Dr. Tatiana Allen was appointed as Associate Head for the physics program. During 2011-2015, the physics program had five (5) tenured/tenure-track faculty members, one full-time lecturer (hired in 2012) with year-to-year appointment, and several adjunct faculty. In the spring of 2015, Dr. Kristin Whitson, assistant professor, did not return to UTC, so currently we have only four (4) tenured/tenure-track faculty members. We are in the process of hiring another lecturer with a hope that that position will eventually evolve into tenure-track line. The number of full-time faculty is broken down according to professional rank in table 4.1.

Table 4.1 Number of full-time faculty according to rank in Fall 2011 and Fall 2016

Professional Rank	Fall 2011	Fall 2016
Professor	3	3
Associate Professor	0	1
Assistant Professor	2	0
Lecturer	0	1

The Program strongly depends on the adjunct instructors to carry the teaching load, especially now when we are trying to hire a full-time faculty line. Currently, the program has four (4) adjuncts.The following roster lists member of the Program according to their current individual rank or position and their expertise.

Fall 2016 Program Roster

Full Time Faculty:

1) Dr. **Tatiana Allen**, UC Foundation Professor of Physics, Associate Head for the Physics Program.
Ph.D.: Physics and Mathematics, St. Petersburg State Technical University, Russia
Area of Expertise: Solid state physics and material science

2) Dr. **Joshua Hamblen**, Associate Professor
Ph.D.: Physics, University of Rochester
Area of Expertise: Experimental nuclear physics

3) Dr. **Robert Marlowe**, Professor of Physics
Ph.D.: Physics, University of Cincinnati
Area of Expertise: Optics and biophysics

4) Dr. **Ling-Jun Wang**, Professor of Physics
Ph.D.: Physics, University of Delaware
Area of Expertise: Cosmology

5) Dr. **Kristin Whitson**, Assistant Professor of Physics
Ph.D.: Molecular Biophysics, Vanderbilt University
Area of Expertise: Experimental biophysics
Departed program in the summer of 2016 and the position is vacant

Lecturer (one-year appointment):
1) Dr. **Seth Waldecker**
Ph.D.: Washington University in St. Louis
Area of Expertise: Theoretical nuclear physics
Joined the Program in 2012

2) Unfilled position – Search in progress

Adjunct Faculty:

1) Mr. **Harold Climer**,
B.S.: Physics, University of Tennessee, Chattanooga
B.S.: Secondary Education, University of Tennessee, Chattanooga
Served as laboratory instructor 1993 – 2014.
Full-time faculty members who taught corresponding lectures supervised Mr. Climer's laboratory sessions.

2) Dr. **Louie Elliot**,
Ph.D.: Computational Engineering, University of Tennessee, Chattanooga
Taught lectures and labs (fall 2010 – spring 2012)

3) Dr. **David Welch**

Ph.D.: Biophysics, University of Boston
Area of Expertise: Experimental biophysics
Joined the Program in spring 2014.

4) Mr. **Dennis Murphy**
Ms.Sc, Engineering Design & Economic Evaluation, University of Colorado, Boulder, CO
Joined the Program in the fall of 2015.

5) Mr. **Jack Pitkin**,
B.S.: Chemistry, University of Tennessee, Chattanooga
Started to teach General Science labs in the spring of 2016.
Full-time faculty member who taught corresponding lectures supervised Mr. Pitkin's laboratory sessions.

6) Dr. **Michael Pugh**
Ed.D., University of Tennessee, Chattanooga
Joined the Program in the fall of 2016.

Academic Support Coordinator:

Jack Pitkin, B.S.: Chemistry, University of Tennessee, Chattanooga
The Academic Support Coordinator, in addition to setting up and taking down equipment for laboratory sessions, is a university-wide radiation safety officer and director of the Jones Observatory.

Administration:

Dr. **Habte G. Churnet**, UC Foundation Professor & Head (2011-spring 2015)
Ph.D.: Geology, University of Tennessee, Knoxville
Area of expertise: Geology

Dr. **Tom Rybolt**, Professor of Chemistry, Head of Department of Chemistry and Physics (Fall 2015-summer 2016)
Ph.D.: Chemistry, Georgia Institute of Technology
Area of expertise: Physical Chemistry

Dr. **Manuel Santiago**, Benjamin H. Gross Professor of Chemistry, Head of Department of Chemistry and Physics (Fall 2016-current)
Ph.D.: Chemistry, South Dakota State University
Area of expertise: Biological Chemistry

Administrative Support:

1**)** Mrs**. Kelly Locke**, BS: Human Ecology
Full-time administrative support personnel for the Department of Physics, Geology and Astronomy (2011-2015)

2) Mrs. **Nancy Tolar**
Full-time administrative support personnel to the Department of Chemistry and Physics (2015-2016)

3) Mrs. **Amy Wensits**
Full-time administrative support personnel to the Department of Chemistry and Physics (2016-present)

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

The full time teaching load (FTE) at UTC is considered 12 credit or 15 contact hours. A typical lecture class (up to 35 students) is considered three (3) credits; large lecture (50-80 students) is considered six (6) credits; labs and recitations (up to 20 students) are one (1) credit/two (2) contact hours. The typical faculty load per semester is one double size lecture, one single size lecture and three labs. All tenure-track faculty members are involved in teaching of large introductory/general education classes as well as upper level classes. Recently we started to teach parallel labs (two (2) adjacent rooms, up to 20 students per room) which allows us to maximize available resources. Our lower level general education classes (algebra-based physics, astronomy, general science) are in very high demand resulting in large (70-80 students) class size. Frequently, we have to turn down students' requests to join closed classes because we just do not have resources to accommodate them. Our upper level classes are growing and reaching double digits in student enrollment numbers due to an increase in the number of physics majors.

Faculty teaching productivity, measured in student credit hours (SCH), is summarized in table 4.2.

Table 4.2: Student Credit Hour Production per Full Time Equivalent

Semester	2012	2013	2014	2015	2016
Fall	351	395	414	409	425
Spring	417	395	451	412	405
Average	384	395	432	410	415

Full Time Equvalent was 4.75 from 2012-2015; 3.75 in 2016.

As one can see, our productivity per FTE is close to 400 SCH. In 2014, physics, geology, and astronomy student credit hour production was 432 SCH/FTE. This number does not take into account teaching individual studies or supervising student research since faculty do not receive credit for teaching these courses. The "National Norm," as determined by the Delaware Study of 2014, is 187 SCH/FTE for physics. We are very much above this benchmark. We desperately need adjunct help, but it is very difficult to find qualified instructors to teach physics/astronomy/general science courses at UTC. Chattanooga is not a high-tech area, where there are many people with advanced degrees in physics or related disciplines, and the adjunct pay precludes drawing qualified workforce from other areas. The lack of qualified adjuncts puts even more teaching demand on the full-time faculty. We believe that these facts justify the need for at least one new tenure-track line for the Program.

Because of such heavy teaching loads, no member of the program has received a sabbatical leave in the period between 2011 and 2016. In fact, the last sabbatical leave that was awarded in the program took place in the fall of 2007.

The Associate Department Head, a position established in the fall of 2015 after the merger with Chemistry Department, has 25% release time from teaching to take care of administrative duties. Release time to concentrate on research is very difficult to come by because of the huge teaching demand. This situation is quite different from, for example, the Department of Mathematics that was able to 1) restructure teaching load to teach only 9 credits per semester, and 2) implement practice of releasing two faculty members per semester (on rotational basis) from teaching a course in order to devote additional time to their research.

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

The Program features a diverse and talented group of international faculty from different countries: China, Russia, and the United States. Until recently, 33% of the full time faculty were women; the recent departure of Dr. Whitson affected this statistic, and currently only 20% are women.

The physics faculty have interests in many areas of the physical sciences, including solid state physics, material science, cosmology, high-energy physics, and biophysics.

The physics faculty received their doctorates from a wide range of prestigious universities: St. Petersburg State Technical University, Russia; University of Rochester; University of Cincinnati; University of Delaware; Vanderbilt University; University of Boston.

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

The faculty are required to complete an annual Evaluation and Development by Objectives (EDO) report. This professional development report consists of two components:

1. Development by objectives
2. Annual evaluation

To complete the development by objectives portion of the EDO report, the faculty must clearly identify their objectives for the upcoming year within each of the following three standard evaluation categories:

1. Instructional and advisement activities
2. Research, scholarly, and creative activities
3. Professional service activities

By completing the development by objectives portion of the EDO report, the department ensures that each faculty member has a professional development plan in place to enhance his or her role as a member of the department and the University.

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

Productivity: The department prides itself on a tradition of active and productive research. In spite of the high teaching load and SCH/FTE ratio, the faculty remain active in research as demonstrated by publications in national and international refereed journals, and presentations at national and international conferences. The number of papers that have appeared in print and the number of presentations by faculty at national and international conferences for the academic years 2011 to 2016 are given in Table 4.4.

Table 4.4

Calendar Year	Publications	Presentations
2011	11	0
2012	5	1

2013	11	1
2014	12	2
2015	5	0
2016	2	5

Grants: The department has been successful in obtaining grants from various internal and external sources to support its research efforts over the past five years. These internal grants take the form of Faculty Development Grants, Faculty Research Grants, UC Foundation Summer Fellowship, UTC ThinkAchieve Grant, and Ruth S. Holmberg Grants for Faculty Excellence, Department of Energy Faculty and Student Team (FaST) Fellowship. These funds are used to support conference presentations and summer research activities.

Continuing Education/ Professional Development: In some cases conferences offer professional development/ short courses/ tutorials that are included in the conference registration fee. However, it is very difficult, if not impossible, to obtain University funds for attendance of continuing education courses without presenting a paper at a conference. As was mentioned earlier, no faculty member has been able to have a sabbatical leave (since 2007) because of very high teaching demands in the program and very limited funding available for sabbaticals at the College/University level.

Awards: Faculty received several prestigious awards, such as the Outstanding Faculty Research and Creative Achievement Award, Outstanding Research Award, UC Foundation Professorship, and Honorary member of the Golden Key International Honor Society. In the area of teaching, perhaps the most rewarding comment is when a student recognizes a faculty member as the professor with the most positive influence during SGA Outstanding Senior Award. We have two physics faculty who received such recognitions during the last 5 years.

Collaborations: Faculty research engagements include collaborations with other professionals at different institutions and with UTC students. Faculty use facilities and collaborate with researchers at Oak Ridge National Laboratory (ORNL), UT-Knoxville, Tennessee Valley Authority, University of Toronto, Covenant College, and A. F. Ioffe Physical-Technical Institute, Russia.

Professional Services: Faculty serve as reviewers to journals such as *Physics Essays*, and *Journal of Biophysical Structure and Dynamics***.** They are members of professional organizations such as American Physical Society, American Society of Physics Teachers, Material Research Society, The Material Society, and The Mendeleev Society (Russia). Faculty participate in national and international meetings and sometimes serve as chairpersons at professional meetings. They also advise students at the Society of Physics Students and UTC's chapter of Sigma Pi Sigma. All faculty members regularly serve on UTC-wide committees (as members or chairpersons) as well as members of Faculty Senate. Faculty also are assigned or elected to chair different functions of the department such as organizing teaching outcomes assessment, scheduling of course offerings per semester, and chairing the Promotion and Tenure Committee.

Faculty serve the wider community by answering questions from the community and occasionally appearing on television to answer the questions of journalists. Faculty, in collaboration with students, present physics demonstrations at area high schools and sometimes present research work to congressional representatives at the state capitol.

Perhaps the department's greatest contribution to our community comes from the Clarence T. Jones Observatory and its Planetarium Annex. The department is extremely fortunate to have a budding amateur astronomer, Jack Pitkin, as a laboratory coordinator in our department. Mr. Pitkin is very active in providing information concerning astronomy to WUTC and other radio and television stations. The local media often contacts the physics faculty for comments on current scientific events.

The number of area school groups, community organizations and families visiting the observatory has increased. Full capacity service is about 40 attendees per open night. On some Sunday evenings, 90 people have come to use the services of the planetarium and the observatory. On high attendance nights, half of those in attendance enjoy lectures on astronomy as the other half experiences the planetarium; then the groups are swapped so that everyone receives the full benefit of the services. Per semester, 300 to 400 people attend the Sunday evening service at UTC's observatory and planetarium. Such outreach will help the department increase its visibility in future years.

4.6 <u>The faculty is actively engaged in planning, evaluation and improvement processes that measure and advance student success.</u>

The faculty are actively involved in advancing student success beyond the classroom in the following ways:

- All decisions that deal with recruitment, course planning and evaluation, general education courses certification and recertification, outcome assessment, advisement, and other aspects that concern with student success involve input from all the program members. The decisions are made either by consensus or by vote, either at the department meetings or by e-mail.
- Faculty members are actively involved in recruiting new majors. This is done through introductory courses, college fairs, open houses, outreach programs, correspondence with Tennessee high schools, etc.
- All tenure-track faculty are involved in student advising. The majors are divided between faculty members evenly, according the first letter of their last name.
- Faculty members are working with students outside classroom to ensure their future success. This is done either through research, Society of Physics Students, field trips, and informal gatherings.
- Faculty members are involved in discussion and decisions concerning the program scholarships and awards.
- Faculty members are involved in writing reference letters to support students' applications for summer research, internships, graduate schools and post-graduate programs.
- All students have direct line of communication with faculty members; most questions and issues are resolved quickly, usually by e-mail.

5. **Learning Resources**

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

Over the course of the semester, periodic reviews of equipment needs are conducted. This is to ensure equipment goals are in alignment with the pedagogical goals of the laboratory experimentation curriculum. One of our goals has been to obtain enough equipment so that two (2) sections of 1000-level labs may be conducted simultaneously. This has had the effect of increasing the efficiency of our student physics lab program.

The most current instrumentation is also sought when older instrumentation no longer functions or has been technologically surpassed with new versions. Instructional equipment is obtained through operating budgets, student laboratory fees, internal and external grants.

In the past five years, the following major equipment acquisitions have been made:

- 36 New Dell OptiPlex 3030 computers for all 3 undergraduate labs. This is a complete upgrade for the three (3) basic physics labs
- 10 digital oscilloscopes for use in advanced labs, research and 2310L labs
- 20 Geiger counter systems
- Upgraded software for Astronomy labs
- 3 State of the art 8-inch Celestron CPC computer controlled telescopes
- Muon Physics M1P1A Lab
- Teach Spin Torsional Oscillator

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

The UTC Library has physics identified articles and databases at http://guides.lib.utc.edu/content.php?pid=137859&sid=1180046 and includes items indicated below:

PHYSICS

General Science Collection (Gale InfoTrac)
Partial Fulltext: Covering all aspects of the sciences, from engineering to geology, physics, nanotechnology, mathematics, and more.

General Science Full Text
Partial Fulltext: Covers astronomy, biology, botany, chemistry, conservation, environment,genetics, physics, physiology, zoology, and more.

ArXiv
Fulltext: Over one million pre-prints in mathematics, computer science, physics, and related disciplines.

Astrophysics Data System Abstract Service
Index: Astronomy, astrophysics, physics, and geophysics literature.

SciTech Connect
Index: Science, technology, and engineering research information from the U.S. Department of Energy.

Web of Science & EndNote Web
Index: Includes Science, Social Science, and Arts and Humanities Citation Indexes from 1988-present

Nature Publishing Group Journals
Partial Fulltext: Over 60 science and medical journals including Nature (1869-current) and Scientific American (1845-current).

Additionally there is a collection of online books http://guides.lib.utc.edu/content.php?pid=137859&sid=1180047 that include sciences as indicated below:

Ask a Librarian!
Call, E-mail, or Chat with a Librarian.

General E-Book Collections:

Springer/Palgrave ebooks
Ebooks: 70,000+ ebooks from 2005-2016 covering sciences, social sciences, and the humanities.

Google Books (some full text - see "About")
Ebooks: Free access to public domain books.

Internet Archive (free e-books)
Ebooks: Free e-books and other texts.

Project Gutenberg (free e-books)
Ebooks: Over 45,000 free e-books

Feedbooks (free e-books)
Ebooks**:** Freely available e-books in public domain

Directory of Open Access Books
Fulltext**:** Free online peer-reviewed e-books.

Browse the Shelf
Call numbers for your subject:
QC – Physics

The indicated websites that the UTC Library refers to can be found using the following link: http://guides.lib.utc.edu/content.php?pid=137859&sid=1180048

The links below can also be found on the Library's website:

Physics Websites

- Resources in Physics

  A list of subject specific resources compiled by the Physics-Astronomy-Mathematics Division of the Special Libraries Association.

- American Physical Society

  "The American Physical Society was founded on May 20, 1899, when 36 physicists gathered at Columbia University for that purpose. They proclaimed the mission of the new Society to be "to advance and diffuse the knowledge of physics", and in one way or another the APS has been at that task ever since."

- American Institute of Physics

  "Dedicated to the advancement of physics, AIP serves a federation of physical science societies, and provides leadership through its own programs and publications."

- Institute of Physics

  "Physics is central to our society. The Institute of Physics aims to advance physics for the benefit of all."

- Physics.org -- Your Guide to Physics on the Web

  Looking for a great physics site? The Institute of Physics has tracked down the very best and checked them for accuracy.

Related to the above and in parallel for Astronomy Articles and Databases, Books and E-books, and Websites the UTC library lists are at websites, respectively:
http://guides.lib.utc.edu/content.php?pid=113731&sid=984009
http://guides.lib.utc.edu/content.php?pid=113731&sid=2991968
http://guides.lib.utc.edu/content.php?pid=113731&sid=984011

Books held by the UTC Library print or by electronic access include 4235 in Physical Sciences including: Physics, General (1121); Constitution & Properties of Matter (1109); Electricity, Magnetism, Nuclear Physics (1083); Optics, Light, Radiation (421); Heat (211); Experimental Mechanics (156); Acoustics, Sound (67); and others (88). Of the previous books, 1264 are from within last five (5) years.

The free access that we have to ArXiv.org maintained by the Cornell University Library does give access to in excess of one million pre-prints in mathematics, computer science, physics, and related disciplines. Within physics it includes all the following areas.

Physcis

- Astrophysics (**astro-ph** new, recent, find)

includes: Astrophysics of Galaxies; Cosmology and Nongalactic Astrophysics; Earth and Planetary Astrophysics; High Energy Astrophysical Phenomena; Instrumentation and Methods for Astrophysics; Solar and Stellar Astrophysics

- Condensed Matter (**cond-mat** new, recent, find)

includes: Disordered Systems and Neural Networks; Materials Science; Mesoscale and Nanoscale Physics; Other Condensed Matter; Quantum Gases; Soft Condensed Matter; Statistical Mechanics; Strongly Correlated Electrons; Superconductivity

- General Relativity and Quantum Cosmology (**gr-qc** new, recent, find)
- High Energy Physics - Experiment (**hep-ex** new, recent, find)
- High Energy Physics - Lattice (**hep-lat** new, recent, find)
- High Energy Physics - Phenomenology (**hep-ph** new, recent, find)
- High Energy Physics - Theory (**hep-th** new, recent, find)
- Mathematical Physics (**math-ph** new, recent, find)
- Nonlinear Sciences (**nlin** new, recent, find) includes:
  Adaptation and Self-Organizing Systems; Cellular Automata and Lattice Gases; Chaotic Dynamics; Exactly Solvable and Integrable Systems; Pattern Formation and Solitons
- Nuclear Experiment (**nucl-ex** new, recent, find)
- Nuclear Theory (**nucl-th** new, recent, find)
- Physics (**physics** new, recent, find) includes:
  Accelerator Physics; Atmospheric and Oceanic Physics; Atomic Physics; Atomic and Molecular Clusters; Biological Physics; Chemical Physics; Classical Physics; Computational Physics; Data Analysis, Statistics and Probability; Fluid Dynamics; General Physics; Geophysics; History and Philosophy of Physics; Instrumentation and Detectors; Medical Physics; Optics; Physics Education; Physics and Society; Plasma Physics; Popular Physics; Space Physics

- Quantum Physics (**quant-ph** new, recent, find)

Finally, we do have a very well-functioning Interlibrary Loan System that is free to students and faculty. Electronic papers and books are usually available within a day to a few days. The resources of the library including what is available through interlibrary loan are adequate for our teaching and research needs.

6. Support

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

The operating budget for the last five years is shown below (Table 6.1A) and has remained fairly constant at approximately $33K per year. The funds have been adequate to maintain large enrollment introductory labs and serve the needs of smaller upper level labs. In addition to expenditures below, there are opportunities for internal grants for research, travel, and classroom/lab improvements. For example, in 2015-16 funds were secured and used for travel, research, and a lab improvement (construction of a cosmic radiation detector in advanced lab).

In 2015-16 funds allocated from the College of Arts and Sciences along with lab fees and operating budget and some gift funds (approximately $32K) were used to purchase over 30 new All-in-One Dell computers for the three main lab rooms in Grote Hall (214, 216, and 217). These computers replaced all of the 6-year old computers (separate monitor and computer) and resulted in providing more bench space and a less cluttered work environment. The introductory physics labs done in these rooms utilize computer interfaced data collection for the experiments.

Table 6.1A Operating Budget for Physics & Astronomy

	2011-2012	**2012-2013**	**2013-2014**	**2014-2015**	**2015-2016**
418000 Student Allocation	6,225	6,225	6,225	6,225	6,225
418000 Student Budget Revisions	(848)	(778)	0	0	(1,500)
418000 Student Total	**5,377**	**5,447**	**6,225**	**6,225**	**4,725**
431000 Travel Allocation	1,975	1,975	1,975	1,975	1,975
431000 Travel Budget Revisions	(1,072)	496	0	729	0
431000 Travel Total	**903**	**2,471**	**1,975**	**2,704**	**1,975**
433000 Media Processing Allocation	1,917	1,917	1,917	1,917	1,917
433000 Media Processing Budget Revisions	1,184	539	0	500	0
433000 Media Processing Total	**3,101**	**2,456**	**1,917**	**2,417**	**1,917**

435000 Communication Allocation	1,100	1,100	1,100	1,100	1,100
435000 Communication Budget Revisions	3,338	3,296	3,591	3,591	0
435000 Communication Total	**4,438**	**4,396**	**4,691**	**4,691**	**1,100**
436000 Maint. & Repair Allocation	1,852	1,852	1,852	1,852	1,852
436000 Maint. & Repair Budget Revisions	(1,540)	(1,540)	0	0	0
436000 Maint. & Repair Budget Total	**312**	**312**	**1,852**	**1,852**	**1,852**
437000 Subscriptions Allocation	0	0	44	44	44
437000 Subscrptions Budget Revisions	0	0	0	0	0
437000 Subscriptions Total	**0**	**0**	**44**	**44**	**44**
439000 Supplies Budget	9,871	9,871	9,871	11,096	11,096
439000 Supplies Budget Revisions	6,061	7,259	1,225	0	9,036
439000 Supplies Total	**15,932**	**17,130**	**11,096**	**11,096**	**20,132**
446000 Contractual & Special Svc.	1,992	1,992	1,992	1,992	1,992
446000 Contr. & Spec. Srv. Budget Revisions	675	4,670	0	0	0
446000 Contr. & Spec. Srvcs Total	**2,667**	**6,662**	**1,992**	**1,992**	**1,992**
449000 Other Allocation	0	0	0	0	0
449000 Other Budget Revisions	0	0	0	1,369	0
449000 Other Total	**0**	**0**	**0**	**1,369**	**0**
Fiscal Year Totals	**32,730**	**38,874**	**29,792**	**32,390**	**33,737**

In addition to the State Budget funds indicated above, there are Scholarship Funds and Physics Program Funds generated annually from endowments. A five-year summary of these expenditures is given below (Table 6.1B). These funds have been used for both student support and for student research.

Table 6.1B: Program Funds

	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	Total
UCF Physics Fund	5,471	5,058	4,792	4,953	5,666	25,940
Scholarships	6,307	5,892	6,078	4,989	6,523	29,789

While the funds have been adequate to sustain the program, an expected increase in research activities and additional students in the department will greatly benefit from supplementary travel funds for faculty and students as well as additional research funds for faculty–student projects.

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

According to the most recent nationwide data from the American Institute of Physics (AIP), there are 496 Bachelors level physics degree offering programs in the country. Among all of these physics programs nationwide, the average number of graduates per year was 6.4 and the median was 5.

According to the American Physics Society's (APS) statistical website that allows us to compare the number of physics degrees awarded nationwide, a comparison of other programs in Tennessee shows that for data available from 2011-2013 the average number of degrees was below 10 for the University of Tennessee at Martin (UTM), Middle Tennessee State University (MTSU), Tennessee State University (TSU), Tennessee Technological University (TTU), and the University of Memphis (UM). East Tennessee State University (ETSU) had 10 per year and UTK averaged 14 graduates. However, UTK has a graduate program and 36 faculty. Given that we have had only four (4) full time tenure track faculty and one (1) full time lecturer, we have fewer faculty than any of the other schools listed above. However, we have Student Credit Hour production well above the National Delaware averages and above our peer schools. Our physics faculty teach heavy loads by providing a great deal of the Natural Science requirements at UTC with courses in astronomy, general science, and physics.

Over the last 5 years UTC has averaged 4 majors per year and last year had 5. We have fewer than 10 majors because that is typical of most of the physics programs in the country. Physics is a demanding math intensive degree, but the need for qualified physics high school teachers is well documented, the need for a technical work force is well known, and the need for future research scientists is ongoing. The number of undergraduate physics majors nationwide is starting to increase.

We can and will increase the number of physics majors and have taken steps to do so as indicated below:

- Flyers with physics program information have been sent to 400 high schools around the state with letters to the physics teachers and a request to encourage interested students to consider UTC.
- A physics faculty member has been designated for future recruitment activities. Physics representation was present at spring and fall UTC high school visitations.

- Five (5) courses were reviewed and eliminated from the curriculum because they were not in demand of the program.

A careful evaluation of all physics courses resulted in a curriculum proposal (approved by the University's Curriculum Committee) to update and clarify 22 lab and lecture courses' pre- and co-requisite requirements.

Requirements have been modified to allow for a better flow of math and physics courses by, for example, allowing a student to take Calculus I in conjunction with the major's Physics I.

- Modification so that a student who does very well in Algebra based Physics I can go on to the major's Calculus based Physics II without having to go back and repeat a course. This will allow students more flexibility to migrate into physics.
- A specific four-year course-offering plan was developed for all physics classes (this was not available previously). This document will help with student planning and the most efficient offering of courses.
- Identified 16 majors admitted to UTC as physics majors and all were contacted by email to encourage their enrollment. They were sent information about the department. These 16 students have an average ACT of 28.
- Publicity for our department-operated Observatory and Planetarium has increased the attendance which helps with community outreach, reputation, and recruitment.
- Scholarships have been available for upper level students but we will redirect some of the funds for freshmen recruitment of exceptionally well-prepared physics majors.
- We will increase recruitment from current classes. We will continue to support and encourage the activities of the Student Physics Society (SPS). For example, the SPS organized a meeting with four (4) speakers on aspects of nuclear power including an active Navy serviceman working on nuclear powered ships.

For fall 2016-17 we will be short one tenure track faculty so we will need a hire for fall 2017 to maintain a minimum of 5 tenured/tenure track faculty. We have one lecturer but need another to meet heavy needs in ASTR, GNSC and PHYS. We are planning to meet our fall 2016 needs with four (4) adjuncts and several full time faculty overloads. We need to increase the number of full-time faculty to five (5) tenure-track and two (2) lecturers.

In a prior study, our physics faculty were shown to be well above peer and National Delaware student credit hour production (see section 4.2). We need to provide for more

opportunities for faculty and student research collaboration. We are taking steps in this direction and we have research collaborations with TVA, Oak Ridge National Lab, and UTK materials science.

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

We have been responsive to local, state, regional, and national needs in that we have programs leading to the BS in Physics, BS in Biophysics and an unusually rigorous STEM physics degree that leads to teacher certification and extensive classroom experience. The need for a technically educated work force is well know and the lack of qualified high school physics teachers is widespread.

We continue to meet the local needs of our campus by providing the natural science requirements of a broad range of UTC students by our offerings in ASTR (astronomy), GNSC (general science), and PHYS (physics).

Approximately 1250 SCH are generated annually in General Science classes in the lecture Natural Science course, Science and Society (GNSC 1150), and the lecture/lab Natural Science course The Physical Environment: Atoms to Galaxies (GNSC 1110). Many students at UTC use these courses to help fulfill their Natural Science general education requirements. Dr. David Welch (adjunct physics) developed an online version of GNSC 1150, and two online classes by two faculty were taught for the first time in spring 2016.

A number of items listed above in section 6.2 indicate our responsiveness to these needs including: our department operated Observatory and Planetarium has increased attendance, which helps with community outreach and science education, and the Student Physics Society (SPS) organized a meeting with four (4) speakers on aspects of nuclear power including an active Navy serviceman working on nuclear powered ships. We are taking steps to maintain and increase research collaborations with TVA, ORNL, and UTK materials science.

An increase in the number and quality of our majors is needed and so we plan to use steps indicated in 6.2 to increase the number of majors, to make sure they are math ready, and to increase the number of graduating B.S. physics students. We want to bring students who can be successful and progress to graduation in physics. Our majors who do graduate are well-qualified but there are other majors who early on are not successful. We want to increase the numbers who can be successful in this challenging major.

In the fall of 2016, we initated a PHYS 1999 special topics course with 13 freshmen physics majors. We have a PHYS 4000 Seminar for junior and senior majors with 10 students enrolled. In fall 2015, we had 7 lectures or labs with single digit enrollments. In fall 2016 we have no physics lectures or labs with single digit enrollment. Our intention is to build up our faculty numbers from the current low point, maintain our large enrollments in astronomy, general science, and introductory physics courses, effectively recruit physics majors, and through lectures, labs, research, scholarship funds, and the unique opportunities of an undergraduate focused program increase the quality of all our majors and the annual number of graduates.

By doing all of the above, we are responsive to the state, regional, and national needs in that it is essential to present to all students aspects of the wonder and power of science. In turn, add to our communities and work force individuals who are critical thinkers and mathematically oriented in analysis and who understand the theory and practice of science with respect to our physical universe.