

# DEPARTMENT OF PHYSICS AND ASTRONOMY

## Mission Statement

The mission of the Physics and Astronomy department is to provide science and engineering students at UTSA with a solid background in physics and problem-solving skills, and equip students with invaluable research experience.

## General Information

The Department of Physics and Astronomy at The University of Texas at San Antonio is a comprehensive academic unit that offers Bachelor of Arts, Bachelor of Science, Master of Science, and Doctoral degrees.

Our faculty members conduct research in a variety of areas including astrophysics and cosmology, biophysics, computational physics, experimental and theoretical condensed matter physics, materials science, and nanotechnology and ultramicroscopy. Students may choose to train in semiconductor technology, solid-state physics, computer visualization, lasers, biophotonics, and theoretical physics. We also offer courses in the exciting areas of astrophysics, cosmology, and relativity for those interested in that frontier.

We strive to provide UTSA science and engineering students with a solid background in physics and problem-solving skills, critical to their future work, regardless of the nature of that work. We also aim to provide students with as much research experience as possible, to better prepare them for their future careers. The jobs available to physics graduates are more varied than what most science majors can find. They range from pure science, to engineering, to finance, to public policy, and, of course, to education.

The academic environment in the Department fosters extensive mentoring of the students, individual contact with instructors, and advanced teaching methodologies. We also offer great opportunities for continuous undergraduate research. Many of our undergraduate students have publications in peer-reviewed journals as well as presentations at regional or national conferences. As a result, our students have been admitted to some of the top graduate programs in the U.S. and have also found employment in the private sector as innovative teachers in public and private schools.

Central goals of the Physics and Astronomy Department are to:

- Become one of the outstanding programs of its kind in the country, in which teaching and research are carefully interwoven for the benefit of the students and the community.
- Encourage groups underrepresented in physics to consider physics or astronomy as their primary career path.
- Be responsive to the needs, both educational and research-related, indispensable in any career but particularly important in science.

## Program Outcomes

The Department of Physics and Astronomy programs provide students graduating with a Bachelor of Science (B.S.) in Physics the opportunity to:

- Have a broad knowledge of all of the areas of physics relevant to modern science and engineering.

- Know advanced physics to enable them to undertake graduate work in physics or start work in the private sector.
- Apply problem-solving skills required to succeed in the private sector or to start graduate work in physics.
- Have the writing skills required in any profession.
- Be proficient in laboratory instrumentation and experimental techniques.

## Degrees

The Department of Physics and Astronomy offers a Bachelor of Science (B.S.) degree in Physics and a Bachelor of Arts (B.A.) degree in Physics (with the option to pursue a Concentration in 6-12 Physical Science Teacher Certification). The Department also offers a Minor in Astronomy/Astrophysics and a Minor in Physics.

The **B.S. Degree in Physics** offers a complete curriculum of advanced undergraduate courses, which includes two semesters of electricity and magnetism, quantum mechanics, and mathematical physics, as well as a rigorous introduction to classical mechanics and statistical thermodynamics. The Bachelor of Science in Physics provides opportunities for preparation for careers in industry and governmental agencies and for graduate study in physics or in college- and university-level teaching and research. Nationally, about half of all B.S. Physics students go on to graduate school, either in physics, engineering, or another professional area.

The **B.A. Degree in Physics** is intended for students seeking a foundation in physics as a liberal arts degree but who typically do not intend to become physicists. The flexibility in this degree program allows students to gain significant educational breadth in other disciplines. The B.A. degree also offers a Concentration in 6-12th Grade Physical Science Teacher Certification, which prepares students for a career in teaching secondary physical science.

## UTeachSA Teacher Preparation Program

UTeachSA (<https://www.utsa.edu/uteachsa/>) is the teacher preparation program in the College of Sciences that prepares students to become secondary (middle school and high school) science and mathematics teachers. The Department of Physics and Astronomy offers one program leading to teacher certification for the state of Texas: B.A. Physics - 6-12th Grade Physical Science Teacher Certification Concentration.

## Criminal History Policy and Acknowledgement for Teacher Preparation Programs

Teacher preparation programs at UTSA require fieldwork in public schools, which requires students to be able to pass a criminal background check. It is the responsibility of the student to determine if their criminal history background will present a problem before applying for admission to the teacher preparation program. Students with a problematic criminal history will encounter difficulty in completing any fieldwork requirements and may not be able to complete the program. The University of Texas at San Antonio is required to inform students of the requirements set forth by the Texas Occupation Code, Chapter 53, Sections 53.001 through 53.105 (<https://statutes.capitol.texas.gov/Docs/OC/htm/OC.53.htm>).

## COS Signature Experiences in Physics and Astronomy

The Department of Physics and Astronomy offers experiential learning opportunities for undergraduate students in which they can gain real-world experiences while also learning about the broader impacts of their work within their fields of study. All undergraduate students have the option to participate in a College of Sciences (COS) Signature Experience. Students should contact the Undergraduate Advisor of Record for the Physics major for a list of relevant signature experiences.

- B.S. Degree in Physics (p. 2)
- B.A. Degree in Physics (p. 4)
- B.A. Degree in Physics with a Concentration in Grades 6-12 Physical Science Teacher Certification (p. 4)

## Bachelor of Science Degree in Physics

The Bachelor of Science (B.S.) degree in Physics provides opportunities for preparation for careers in industry and governmental agencies and for graduate study in physics or related fields.

A minimum number of 120 semester credit hours is required for the B.S. in Physics, including Core Curriculum requirements. At least 39 of the total semester credit hours required for the degree must be at the upper-division level.

All major and support work courses (including math, chemistry, and computer science courses) must be completed with a grade of "C-" or better.

### Core Curriculum Requirements (42 semester credit hours)

Students seeking the B.S. degree in Physics must fulfill University Core Curriculum requirements in the same manner as other students. The courses listed below satisfy both major requirements and Core Curriculum requirements; however, if these courses are taken to satisfy both requirements, then students may need to take additional courses in order to meet the minimum number of semester credit hours required for this degree.

MAT 1213 may be used to satisfy the core requirement in Mathematics as well as a major requirement.

PHY 1943 and PHY 1963 may be used to satisfy the core requirement in Life and Physical Sciences as well as major requirements.

### Core Curriculum Component Area Requirements (<http://catalog.utsa.edu/undergraduate/bachelorsdegreeregulations/degerequirements/corecurriculumcomponentarearequirements/>)

First Year Experience Requirement	3
Communication	6
Mathematics	3
Life and Physical Sciences	6
Language, Philosophy and Culture	3
Creative Arts	3
American History	6
Government-Political Science	6
Social and Behavioral Sciences	3

Component Area Option	3
<b>Total Credit Hours</b>	<b>42</b>

### Gateway Courses

Students pursuing the B.S. degree in Physics must successfully complete each of the following Gateway Courses with a grade of "C-" or better in no more than two attempts. A student who is unable to successfully complete these courses within two attempts, including dropping a course with a grade of "W" or taking an equivalent course at another institution, will be required to change their major.

Code	Title	Credit Hours
PHY 2103 & PHY 2111	Modern Physics and Modern Physics Laboratory	
PHY 2823	Mathematical Physics I	
PHY 3203	Classical Mechanics I	

### Degree Requirements

Code	Title	Credit Hours
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#### A. Physics and Astronomy courses

1. Required courses completed with a grade of "C-" or better:		
PHY 1943 & PHY 1951	Physics for Scientists and Engineers I and Physics for Scientists and Engineers I Laboratory	4
PHY 1963 & PHY 1971	Physics for Scientists and Engineers II and Physics for Scientists and Engineers II Laboratory	4
PHY 2103 & PHY 2111	Modern Physics and Modern Physics Laboratory	4
PHY 2823	Mathematical Physics I	3
PHY 3203	Classical Mechanics I	3
PHY 3293	Thermal Physics	3
PHY 3343	Physics Research Laboratory	3
PHY 3423	Electricity and Magnetism	3
PHY 3443	Modern Optics	3
PHY 3513	Electrodynamics	3
PHY 3583	Mathematical Physics II	3
PHY 4263	Quantum Mechanics I	3
PHY 4423	Quantum Mechanics II	3
PHY 4983	Unifying Concepts in Physics	3
2. 9 additional approved semester credit hours selected from the following (a maximum of 6 hours from either PHY 4911-3 or PHY 4953 may apply to this requirement):		
AST 3013	Fundamentals of Astronomy	
AST 3023	Introduction to Astrophysics	
PHY 3313	Materials Physics	
PHY 3453	Lasers: Theory and Applications	
PHY 3603	Cosmology	
PHY 4013	Relativity: Special and General	
PHY 4623	Nanotechnology	
PHY 4833	Molecular Biophysics	
PHY 4911	Independent Study	
PHY 4953	Special Studies in Physics	

PHY 4993	Directed Research	
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**B. Required courses in the College of Sciences**

## 1. Required courses (excluding physics):

CHE 1103	General Chemistry I	3
CHE 1113	General Chemistry II	3
CHE 1121	General Chemistry I Laboratory	1
CS 1063 or CS 1173 or CS 2073	Introduction to Computer Programming I Data Analysis and Visualization Computer Programming with Engineering Applications	3
MAT 1213	Calculus I	3
MAT 1223	Calculus II	3
MAT 2213	Calculus III	3
MAT 2233	Linear Algebra	3
MAT 3613	Differential Equations I	3

2. Additional approved courses in the College of Sciences. 5

**Total Credit Hours** 84**Course Sequence Guide for B.S. Degree in Physics**

This course sequence guide is designed to assist students in completing their B.S. Degree in Physics. *This course sequence is only a guide and students must satisfy other requirements of this catalog and meet with their academic advisor for individualized degree plans.* Progress within this guide depends upon such factors as course availability, individual student academic preparation, student time management, work obligations, and individual financial considerations. **Students may choose to take courses during Summer terms to reduce course loads during long semesters.**

**B.S. in Physics – Recommended Four-Year Academic Plan****First Year**

Fall		Credit Hours
AIS 1243	AIS: Engineering, Mathematics, and Sciences	3
CHE 1103	General Chemistry I	3
CHE 1121	General Chemistry I Laboratory <sup>1</sup>	1
CS 1063 or CS 1173 or CS 2073	Introduction to Computer Programming I or Data Analysis and Visualization or Computer Programming with Engineering Applications	3
MAT 1213	Calculus I	3
WRC 1013	Freshman Composition I (core)	3
	<b>Credit Hours</b>	<b>16</b>

**Spring**

CHE 1113	General Chemistry II	3
MAT 1223	Calculus II	3
PHY 1943 & PHY 1951	Physics for Scientists and Engineers I and Physics for Scientists and Engineers I Laboratory (core and major)	4
WRC 1023	Freshman Composition II (core)	3
	<b>Credit Hours</b>	<b>13</b>

**Second Year****Fall**

MAT 2213	Calculus III	3
MAT 2233	Linear Algebra	3
PHY 1963 & PHY 1971	Physics for Scientists and Engineers II and Physics for Scientists and Engineers II Laboratory (core and major)	4
POL 1013	Introduction to American Politics (core)	3

**Credit Hours** 13**Spring**

MAT 3613	Differential Equations I	3
PHY 2103	Modern Physics	3
PHY 2111	Modern Physics Laboratory	1
PHY 2823	Mathematical Physics I	3
PHY 3203	Classical Mechanics I	3
American History (core)		3

**Credit Hours** 16**Third Year****Fall**

PHY 3293	Thermal Physics	3
PHY 3423	Electricity and Magnetism	3
PHY 3443	Modern Optics	3
PHY 3583	Mathematical Physics II	3
POL 1133 or POL 1213	Texas Politics and Society (core) or Civil Rights in Texas and America	3

**Credit Hours** 15**Spring**

PHY 3343	Physics Research Laboratory	3
PHY 3513	Electrodynamics	3
PHY 4263	Quantum Mechanics I	3
Language, Philosophy & Culture (core)		3
Social & Behavioral Sciences (core)		3

**Credit Hours** 15**Fourth Year****Fall**

PHY 4423	Quantum Mechanics II	3
College of Sciences elective		3
Upper-division AST or PHY elective <sup>2</sup>		3
Upper-division AST or PHY elective <sup>2</sup>		3
American History (core)		3

**Credit Hours** 15**Spring**

PHY 4983	Unifying Concepts in Physics	3
College of Sciences elective		2
College of Sciences elective		3
Upper-division AST or PHY elective <sup>2</sup>		3
Creative Arts (core)		3

Component Area Option (core)	3
<b>Credit Hours</b>	<b>17</b>
<b>Total Credit Hours</b>	<b>120</b>

<sup>1</sup> This laboratory course includes a lecture component as indicated on the University Schedule of Classes.

<sup>2</sup> From section A.2. of degree requirements.

**Note:** Some courses are only offered once a year: Fall or Spring. Check with the Department of Physics and Astronomy for scheduling of courses.

## Bachelor of Arts Degree in Physics

The Bachelor of Arts (B.A.) degree in Physics provides opportunities for careers in several professional fields. It is not recommended for students planning to pursue graduate studies in physics or related fields.

A minimum number of 120 semester credit hours is required for the B.A. in Physics, including Core Curriculum requirements. At least 39 of the total semester credit hours required for the degree must be at the upper-division level.

All majors in physics are required to complete all required and elective physics courses with a grade of "C-" or better.

### Core Curriculum Requirements (42 semester credit hours)

Students seeking the B.A. degree in Physics must fulfill University Core Curriculum requirements in the same manner as other students. The courses listed below satisfy both degree requirements and Core Curriculum requirements; however, if these courses are taken to satisfy both requirements, then students may need to take additional courses in order to meet the minimum number of semester credit hours required for this degree.

MAT 1213 may be used to satisfy the core requirement in Mathematics as well as a major requirement.

PHY 1943 and PHY 1963 may be used to satisfy the core requirement in Life and Physical Sciences as well as major requirements.

### Core Curriculum Component Area Requirements (<http://catalog.utsa.edu/undergraduate/bachelorsdegreeregulations/degreerequirements/corecurriculumcomponentarearequirements/>)

First Year Experience Requirement	3
Communication	6
Mathematics	3
Life and Physical Sciences	6
Language, Philosophy and Culture	3
Creative Arts	3
American History	6
Government-Political Science	6
Social and Behavioral Sciences	3
Component Area Option	3
<b>Total Credit Hours</b>	<b>42</b>

### Gateway Courses

Students pursuing the B.A. degree in Physics must successfully complete each of the following Gateway Courses with a grade of "C-" or better in

no more than two attempts. A student who is unable to successfully complete these courses within two attempts, including dropping a course with a grade of "W" or taking an equivalent course at another institution, will be required to change their major.

Code	Title	Credit Hours
PHY 2103 & PHY 2111	Modern Physics and Modern Physics Laboratory	
PHY 2823	Mathematical Physics I	
PHY 3203	Classical Mechanics I	

### Degree Requirements

Code	Title	Credit Hours
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#### A. Physics and Astronomy courses

1. Required courses completed with a grade of "C-" or better:		
PHY 1943 & PHY 1951	Physics for Scientists and Engineers I and Physics for Scientists and Engineers I Laboratory	4
PHY 1963 & PHY 1971	Physics for Scientists and Engineers II and Physics for Scientists and Engineers II Laboratory	4
PHY 2103 & PHY 2111	Modern Physics and Modern Physics Laboratory	4
PHY 2823	Mathematical Physics I	3
PHY 3203	Classical Mechanics I	3
PHY 3293	Thermal Physics	3
PHY 3343	Physics Research Laboratory	3
PHY 3423	Electricity and Magnetism	3
2. Select two additional courses from the following:		
AST 3013	Fundamentals of Astronomy	
AST 3023	Introduction to Astrophysics	
PHY 3313	Materials Physics	
PHY 3443	Modern Optics	
PHY 3603	Cosmology	
PHY 4013	Relativity: Special and General	
PHY 4263	Quantum Mechanics I	

#### B. Required courses in the College of Sciences

1. Required courses (excluding physics):		
CHE 1103	General Chemistry I	3
CHE 1113	General Chemistry II	3
CHE 1121	General Chemistry I Laboratory	1
CS 1063	Introduction to Computer Programming I	3
or CS 1173	Data Analysis and Visualization	
or CS 2073	Computer Programming with Engineering Applications	
MAT 1213	Calculus I	3
MAT 1223	Calculus II	3
MAT 2213	Calculus III	3
2. Additional approved courses from the College of Sciences (including at least 21 hours of upper-division coursework).		35
<b>Total Credit Hours</b>		<b>87</b>

## Concentrations

The B.A. degree in Physics offers one concentration for students interested in becoming 6-12th grade Physical Sciences teacher offered through the UTeachSA program.

### Concentration in Grades 6–12 Physical Science Teacher Certification

The B.A. degree in Physics with a Concentration in Grades 7-12 Physical Science Teacher Certification is designed to prepare students for professional careers in teaching Physical Science, including physics and chemistry, at the secondary level. The program of study is structured around a comprehensive Physics curriculum and state requirements for grades 6–12 physical science teaching certification. Students cannot receive a B.A. degree with Teacher Certification without completing the teacher certification coursework. A student who does not complete the Physical Science teacher certification must transfer to the general B.A. or B.S. in Physics program.

The coursework within the Concentration in Grades 6–12 Physical Science Teacher Certification must be completed with a minimum cumulative grade point average of 2.5 or better.

### Criminal Background Check

Teacher preparation programs at UTSA requires fieldwork in public schools. This requires that a student be able to pass a criminal background check conducted by the school districts. It is the responsibility of the student to determine if their criminal history background will present a problem before applying for admission to the teacher preparation program. Students with a problematic criminal history will encounter difficulty in completing any fieldwork requirements and may not be able to complete the program.

All candidates for the Concentration in Grades 6–12 Physical Science Teacher Certification must complete the following:

Code	Title	Credit Hours
ESL 3083	Second Language Teaching and Learning for Grades 7-12	3
LTED 3773	Reading and Writing Across the Disciplines-Grades 7–12	3
SPE 3603	Introduction to Special Education	3
UTE 1111	Introduction to STEM Teaching Step 1	1
UTE 1122	Introduction to STEM Teaching Step 2	2
UTE 3023	Perspectives on Science and Mathematics	3
UTE 3203	Knowing and Learning in Mathematics and Science	3
UTE 3213	Classroom Interactions	3
UTE 4203	Project-Based Instruction	3
UTE 4646	Clinical Teaching	6
<b>Total Credit Hours</b>		<b>30</b>

## Course Sequence Guides for B.A. Degree in Physics

This course sequence guide is designed to assist students in completing their UTSA undergraduate Physics degree requirements. *This course sequence is only a guide and students must satisfy other requirements of this catalog and meet with their academic advisor for individualized degree plans.* Progress within this guide depends upon such factors as course availability, individual student academic preparation, student time management, work obligations, and individual financial

considerations. **Students may choose to take courses during Summer terms to reduce course loads during long semesters.**

### B.A. in Physics – Recommended Four-Year Academic Plan

#### First Year

Fall		Credit Hours
AIS 1243	AIS: Engineering, Mathematics, and Sciences	3
CHE 1103	General Chemistry I	3
CHE 1121	General Chemistry I Laboratory <sup>1</sup>	1
CS 1063 or CS 1173 or CS 2073	Introduction to Computer Programming I or Data Analysis and Visualization or Computer Programming with Engineering Applications	3
MAT 1213	Calculus I (core and major)	3
WRC 1013	Freshman Composition I (core)	3
<b>Credit Hours</b>		<b>16</b>

#### Spring

CHE 1113	General Chemistry II	3
MAT 1223	Calculus II	3
PHY 1943 & PHY 1951	Physics for Scientists and Engineers I and Physics for Scientists and Engineers I Laboratory (core and major)	4
WRC 1023	Freshman Composition II (core)	3
College of Sciences elective <sup>2</sup>		2
<b>Credit Hours</b>		<b>15</b>

#### Second Year

Fall		Credit Hours
MAT 2213	Calculus III	3
PHY 1963 & PHY 1971	Physics for Scientists and Engineers II and Physics for Scientists and Engineers II Laboratory (core and major)	4
	Social & Behavioral Sciences (core)	3
	American History (core)	3
<b>Credit Hours</b>		<b>13</b>

#### Spring

PHY 2103	Modern Physics	3
PHY 2111	Modern Physics Laboratory	1
PHY 2823	Mathematical Physics I	3
PHY 3203	Classical Mechanics I	3
	American History (core)	3
	Component Area Option (core)	3
<b>Credit Hours</b>		<b>16</b>

#### Third Year

Fall		Credit Hours
PHY 3293	Thermal Physics	3
PHY 3423	Electricity and Magnetism	3
	College of Sciences elective <sup>2</sup>	3
	College of Sciences elective <sup>2</sup>	3

Language, Philosophy & Culture (core)		3
<b>Credit Hours</b>		<b>15</b>
<b>Spring</b>		
PHY 3343	Physics Research Laboratory	3
POL 1133 or POL 1213	Texas Politics and Society (core) or Civil Rights in Texas and America	3
College of Sciences elective <sup>2</sup>		3
College of Sciences elective <sup>2</sup>		3
College of Sciences elective <sup>2</sup>		3
<b>Credit Hours</b>		<b>15</b>
<b>Fourth Year</b>		
<b>Fall</b>		
POL 1013	Introduction to American Politics (core)	3
College of Sciences elective <sup>2</sup>		3
College of Sciences elective <sup>2</sup>		3
College of Sciences elective <sup>2</sup>		3
Upper-division AST or PHY elective <sup>3</sup>		3
<b>Credit Hours</b>		<b>15</b>
<b>Spring</b>		
College of Sciences elective <sup>2</sup>		3
College of Sciences elective <sup>2</sup>		3
College of Sciences elective <sup>2</sup>		3
Upper-division AST or PHY elective <sup>3</sup>		3
Creative Arts (core)		3
<b>Credit Hours</b>		<b>15</b>
<b>Total Credit Hours</b>		<b>120</b>

<sup>1</sup> This laboratory course includes a lecture component as indicated on the University Schedule of Classes.

<sup>2</sup> At least 21 semester credit hours of College of Sciences electives must be at the upper-division level.

<sup>3</sup> From section A.2. of degree requirements.

**Note:** Some courses are only offered once a year: Fall or Spring. Check with the Department of Physics and Astronomy for scheduling of courses.

**B.A. in Physics with a Concentration in 6-12 Physical Science Teacher Concentration – Recommended Four-Year Academic Plan**

<b>First Year</b>		
<b>Fall</b>		
AIS 1203	Academic Inquiry and Scholarship (core)	3
CS 1063 or CS 1173 or CS 2073	Introduction to Computer Programming I or Data Analysis and Visualization or Computer Programming with Engineering Applications	3
MAT 1213	Calculus I (core)	3
UTE 1111	Introduction to STEM Teaching Step 1	1
<b>Credit Hours</b>		<b>15</b>

WRC 1013	Freshman Composition I (core)	3
<b>Credit Hours</b>		<b>13</b>
<b>Spring</b>		
MAT 1223	Calculus II	3
PHY 1943 & PHY 1951	Physics for Scientists and Engineers I and Physics for Scientists and Engineers I Laboratory (core)	4
UTE 1122	Introduction to STEM Teaching Step 2	2
WRC 1023	Freshman Composition II (core)	3
American History (core)		3
<b>Credit Hours</b>		<b>15</b>
<b>Summer</b>		
American History (core)		3
Component Area Option (core)		3
Social and Behavioral Sciences (core)		3
<b>Credit Hours</b>		<b>9</b>
<b>Second Year</b>		
<b>Fall</b>		
CHE 1103	General Chemistry I	3
CHE 1121	General Chemistry I Laboratory	1
PHY 1963 & PHY 1971	Physics for Scientists and Engineers II and Physics for Scientists and Engineers II Laboratory	4
UTE 3203	Knowing and Learning in Mathematics and Science	3
Creative Arts (core)		3
<b>Credit Hours</b>		<b>14</b>
<b>Spring</b>		
MAT 2213	Calculus III	3
UTE 3213	Classroom Interactions	3
Government-Political Science (core)		3
Government-Political Science (core)		3
Language, Philosophy and Culture (core)		3
<b>Credit Hours</b>		<b>15</b>
<b>Third Year</b>		
<b>Fall</b>		
CHE 1113	General Chemistry II	3
PHY 2103	Modern Physics	3
PHY 2111	Modern Physics Laboratory	1
UTE 3023	Perspectives on Science and Mathematics	3
Upper-division PHY elective		3
Upper-division PHY elective		2
<b>Credit Hours</b>		<b>15</b>
<b>Spring</b>		
PHY 2823	Mathematical Physics I	3
PHY 3203	Classical Mechanics I	3
PHY 3343	Physics Research Laboratory	3
SPE 3603	Introduction to Special Education	3

UTE 4203	Project-Based Instruction	3
<b>Credit Hours</b>		<b>15</b>

**Fourth Year****Fall**

ESL 3083	Second Language Teaching and Learning for Grades 7-12	3
LTED 3773	Reading and Writing Across the Disciplines-Grades 7-12	3
PHY 3423	Electricity and Magnetism	3
PHY 3293	Thermal Physics	3
Upper-division PHY elective		3
<b>Credit Hours</b>		<b>15</b>

**Spring**

UTE 4646	Clinical Teaching	6
College of Sciences elective		3
<b>Credit Hours</b>		<b>9</b>
<b>Total Credit Hours</b>		<b>120</b>

**Note:** Some courses are only offered once a year: Fall or Spring. Check with the Department of Physics and Astronomy for scheduling of courses.

- Minor in Astronomy/Astrophysics (p. 7)
- Minor in Physics (p. 7)

## Minor in Astronomy/Astrophysics

The Department of Physics and Astronomy offers a Minor in Astronomy/Astrophysics, which serves to increase the value of the student's major concentration. The minor provides a more comprehensive foundation in physics to those wishing to teach science at the middle and high school levels through applications of important physics concepts. Further, it is a key Science, Technology, Engineering, and Mathematics (STEM) subject, due to its critical science, technology, and math components, combined with a popular appeal.

All students pursuing the Minor in Astronomy/Astrophysics must complete 20 semester credit hours.

Code	Title	Credit Hours
<b>A. Required Courses</b>		
AST 3013	Fundamentals of Astronomy	3
AST 3023	Introduction to Astrophysics	3
PHY 1943 & PHY 1951	Physics for Scientists and Engineers I and Physics for Scientists and Engineers I Laboratory	4
PHY 1963 & PHY 1971	Physics for Scientists and Engineers II and Physics for Scientists and Engineers II Laboratory	4
<b>B. Select two of the following courses</b>		<b>6</b>
PHY 3603	Cosmology	
AST 4203	Stellar Astrophysics	
AST 4953	Special Studies in Astronomy	
<b>Total Credit Hours</b>		<b>20</b>

To declare a Minor in Astronomy/Astrophysics, obtain advice, or seek approval of substitutions for course requirements, students should consult their academic advisor.

## Minor in Physics

The Department of Physics and Astronomy also offers a Minor in Physics, which serves to increase the value of the student's major concentration. It also provides a more solid foundation in physics to those wishing to teach science at the middle and high school levels.

All students pursuing the Minor in Physics must complete 21 semester credit hours.

Code	Title	Credit Hours
<b>Required courses:</b>		
PHY 1943 & PHY 1951	Physics for Scientists and Engineers I and Physics for Scientists and Engineers I Laboratory	4
PHY 1963 & PHY 1971	Physics for Scientists and Engineers II and Physics for Scientists and Engineers II Laboratory	4
PHY 2103 & PHY 2111	Modern Physics and Modern Physics Laboratory	4
PHY 3203	Classical Mechanics I	3
PHY 3293	Thermal Physics	3
PHY 3423	Electricity and Magnetism	3
<b>Total Credit Hours</b>		<b>21</b>

To declare a Minor in Physics, obtain advice, or seek approval of substitutions for course requirements, students should consult their academic advisor.

## Astronomy (AST) Courses

**AST 1013. Introduction to Astronomy. (3-0) 3 Credit Hours. (TCCN = ASTR 1303)**

Prerequisite: MAT 1023 or MAT 1073. A descriptive course including the development of astronomy, its methods, and the motions, laws, and evolution of the solar system. Topics include general properties and types of stars, unusual stellar objects such as quasars and black holes, galaxies, evolution, and cosmology. Occasional evening viewing sessions are held. May apply toward the Core Curriculum requirement in Life and Physical Sciences. Generally offered: Fall, Spring, Summer. Course Fees: LRC1 \$12; LRS1 \$46.20; MEPA \$18; STSI \$21.60; DL01 \$75.

**AST 1031. Introduction to Astronomy Laboratory. (1-2) 1 Credit Hour. (TCCN = ASTR 1103)**

Prerequisite: Completion of or concurrent enrollment in AST 1013, or consent of instructor. This course is an introduction to practical observational techniques, using the school's telescopes as well as student-built classical instruments and exercises in the use of the telescope and certain other astronomical instruments, including simple observations, measurements, and photography. Topics include in-class projects on spectroscopy, stellar positions, solar heating, planetary motions, solar and astrophotography, star clusters, galaxies, and cosmology. Generally offered: Fall, Spring. Course Fees: LRC1 \$4; LRS1 \$15.40; MEPA \$18; STSI \$7.20.

**AST 1033. Exploration of the Solar System. (3-0) 3 Credit Hours. (TCCN = ASTR 1304)**

Prerequisite: MAT 1023 or MAT 1073. A descriptive course of modern studies of the solar system, including a survey of the properties of the planets and smaller bodies (asteroids and comets) and current theories of the origin of planetary systems. Topics include results from the latest satellite, robotic, and human exploration of space, origin of life in the solar system, existence of other planetary systems, possibilities of space colonization, and the search for extraterrestrial life (techniques and possibilities of communication with other intelligences). May apply toward the Core Curriculum requirement in Life and Physical Sciences. Generally offered: Fall, Spring. Course Fees: LRC1 \$12; LRS1 \$46.20; MEPA \$18; STSI \$21.60; DL01 \$75.

**AST 3013. Fundamentals of Astronomy. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963 and MAT 1223 (or MAT 1224 in previous catalogs), or MAT 1193 and STA 1403, completed with a grade of "C-" or better. This is a one-semester introductory survey course on modern astronomy for science and engineering majors. Students need to be comfortable with solving problems and using math as a tool to help master the course material. Students concerned about their problem-solving and math skills should consider taking AST 1013 instead, which is intended for non-science majors. Among the topics covered are the celestial sphere, basic orbit theory, stellar parameters, binary stars and light curves, and basic introduction to stellar spectral classification. (Formerly AST 2063 in previous catalogs. Credit cannot be earned for both AST 3013 and AST 2063.) Generally offered: Fall. This course has Differential Tuition. Course Fee: DL01 \$75; MEPA \$18.

**AST 3023. Introduction to Astrophysics. (3-0) 3 Credit Hours.**

Prerequisite: AST 3013 or consent of instructor. Topics include an introduction to stellar structure and evolution, stellar atmospheres, collapsed stars, galactic structure, introduction to cosmology, etc. (Formerly AST 3003 and PHY 4003 in previous catalogs. Credit cannot be earned for more than one of the following: AST 3003, AST 3023, or PHY 4003.) Generally offered: Spring. This course has Differential Tuition. Course Fee: MEPA \$18; DL01 \$75.

**AST 4203. Stellar Astrophysics. (3-0) 3 Credit Hours.**

Prerequisite: AST 3023 or consent of instructor. Topics include properties and evolution of stars, stellar atmospheres, stellar spectra, nuclear reactions, stellar models, equations of state, radiative transfer, nucleosynthesis in stars, supernovae, and degenerate stars. This course has Differential Tuition.

**AST 4953. Special Studies in Astronomy. (3-0) 3 Credit Hours.**

Prerequisites: AST 3023 and consent of instructor. An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Studies may be repeated for credit when the topics vary, but not more than 6 semester credit hours, regardless of discipline, will apply to a bachelor's degree. This course has Differential Tuition. Course fee: DL01 \$75.

## Physics (PHY) Courses

**PHY 1603. Algebra-based Physics I. (3-0) 3 Credit Hours. (TCCN = PHYS 1301)**

Prerequisite: MAT 1023 or MAT 1073 completed with a grade of "C-" or better; concurrent enrollment in PHY 1611 is recommended. The first of a two-part, algebra-based introduction to physics for biology and other majors that do not require calculus-based physics. Topics include mechanics, thermodynamics, vibrations and waves. Generally offered: Fall, Spring, Summer. Course Fees: LRS1 \$46.20; MEPA \$18; STSI \$21.60; DL01 \$75.

**PHY 1611. Algebra-based Physics I Laboratory. (1-3) 1 Credit Hour. (TCCN = PHYS 1101)**

Prerequisite: Completion of or concurrent enrollment in PHY 1603. Laboratory accompanies PHY 1603; uses modern data acquisition and analysis tools to study the classic physics experiments that underlie the concepts discussed in PHY 1603. Generally offered: Fall, Spring, Summer. Course Fees: IUP1 \$20; LRS1 \$15.40; STSI \$7.20; DL01 \$25.

**PHY 1623. Algebra-based Physics II. (3-0) 3 Credit Hours. (TCCN = PHYS 1302)**

Prerequisite: PHY 1603 completed with a grade of "C-" or better; concurrent enrollment in PHY 1631 is recommended. The second of a two-part, algebra-based introduction to physics for biology and other majors that do not require calculus-based physics. Topics include electricity, magnetism, optics, relativity, and quantum physics. Generally offered: Fall, Spring, Summer. Course Fees: LRS1 \$46.20; MEPA \$18; STSI \$21.60; DL01 \$75.

**PHY 1631. Algebra-based Physics II Laboratory. (1-3) 1 Credit Hour. (TCCN = PHYS 1102)**

Prerequisites: PHY 1611 completed with a grade of "C-" or better and completion of or concurrent enrollment in PHY 1623. Laboratory accompanies PHY 1623; uses modern data acquisition and analysis tools to study the classic physics experiments that underlie the concepts discussed in PHY 1623. Generally offered: Fall, Spring, Summer. Course Fees: IUP1 \$20; LRS1 \$15.40; STSI \$7.20; DL01 \$25.

**PHY 1943. Physics for Scientists and Engineers I. (3-1) 3 Credit Hours. (TCCN = PHYS 2325)**

Prerequisite: MAT 1193 or MAT 1213 (or MAT 1214 in previous catalogs) with a grade of "C-" or better; completion of or concurrent enrollment in MAT 1223 (or MAT 1224 in previous catalogs) (if student took MAT 1213 or MAT 1214), or STA 1403 (if student took MAT 1193) is required; concurrent enrollment in PHY 1951 is recommended. The first of a two-part, calculus-based introduction to classical physics, designed for physical sciences, mathematics, and engineering majors. Topics include mechanics and Newton's laws, conservation laws, gravitation, rotational motion and rigid bodies, oscillations and waves. Classes meet weekly for three hours of lecture and one hour of recitation. May apply toward the Core Curriculum requirement in Life and Physical Sciences. (Formerly PHY 1903 and PHY 1904. Credit cannot be earned for more than one of the following: PHY 1903, PHY 1904, or PHY 1943.) Generally offered: Fall, Spring, Summer. Course Fee: LRC1 \$12; LRS1 \$46.20; MEPA \$18; STSI \$21.60; DL01 \$75.

**PHY 1951. Physics for Scientists and Engineers I Laboratory. (1-3) 1 Credit Hour.**

Prerequisite: Completion of, with a grade of "C-" or better, or concurrent enrollment in PHY 1943. Laboratory to accompany PHY 1943; uses modern data acquisition and analysis tools to study the classic physics experiments that underlie the concepts discussed in PHY 1943. (Formerly PHY 1911. Credit cannot be earned for both PHY 1951 and PHY 1911.) Generally offered: Fall, Spring, Summer. Course Fee: IUP1 \$20; LRS1 \$15.40; STSI \$7.20; DL01 \$25.

**PHY 1963. Physics for Scientists and Engineers II. (3-1) 3 Credit Hours. (TCCN = PHYS 2326)**

Prerequisite: PHY 1943, and MAT 1223 (or MAT 1224 in previous catalogs) or (MAT 1193 and STA 1403) completed with grades of "C-" or better; concurrent enrollment in PHY 1971 is recommended. The second of a two-part, calculus-based introduction to classical physics, designed for physical sciences, mathematics, and engineering majors. Topics include an introduction to thermal physics, electricity and magnetism, fundamentals of circuits, electromagnetic induction, AC circuits, electromagnetic waves, and Maxwell's equations. Classes meet weekly for three hours of lecture and one hour of recitation. May apply toward the Core Curriculum requirement in Life and Physical Sciences. (Formerly PHY 1923 and PHY 1924. Credit cannot be earned for more than one of the following: PHY 1923, PHY 1924, or PHY 1963.) Generally offered: Fall, Spring, Summer. Course Fee: LRS1 \$12; LRS1 \$46.20; MEPA \$18; STSI \$21.60; DL01 \$75.

**PHY 1971. Physics for Scientists and Engineers II Laboratory. (1-3) 1 Credit Hour.**

Prerequisite: PHY 1951 completed with a grade of "C-" or better and completion of or concurrent enrollment in PHY 1963. Laboratory to accompany PHY 1963; uses modern data acquisition and analysis tools to study the classic physics experiments that underlie the concepts discussed in PHY 1963. (Formerly PHY 1931. Credit cannot be earned for both PHY 1971 and PHY 1931.) Generally offered: Fall, Spring, Summer. Course Fee: IUP1 \$20; LRS1 \$15.40; STSI \$7.20; DL01 \$25.

**PHY 2103. Modern Physics. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963 or MAT 2213 (or MAT 2214 in previous catalogs) completed with a grade of "C-" or better, and completion of or concurrent enrollment in PHY 3203, or consent of instructor. Topics include special relativity, Planck's Radiation Law, elements of quantum mechanics, atomic and molecular structures, spectra, the atomic nucleus, nuclear reactions, and an introduction to elementary particles. (Formerly PHY 3103. Credit cannot be earned for both PHY 2103 and PHY 3103.) Generally offered: Fall, Spring. Course Fee: LRS1 \$46.20; STSI \$21.60; DL01 \$75.

**PHY 2111. Modern Physics Laboratory. (1-3) 1 Credit Hour.**

Prerequisites: PHY 1963, PHY 1971, and completion of, with a grade of "C-" or better, or concurrent enrollment in PHY 2103. Laboratory to accompany PHY 2103; Uses modern data acquisition and analysis tools to study the classic physics experiments that underlie the concepts discussed in PHY 2103. Generally offered: Fall, Spring. Course Fees: IUP1 \$20; LRS1 \$15.40; STSI \$7.20; DL01 \$25.

**PHY 2823. Mathematical Physics I. (3-0) 3 Credit Hours.**

Prerequisite: MAT 2213 (or MAT 2214 in previous catalogs), and PHY 1963, or consent of instructor. Topics may include vector analysis, introduction to complex variables, Fourier series, ordinary differential equations, linear algebra, and selected applications to problems in mechanics and electromagnetic theory. All sections of this course have a Mathematica software component to illustrate and reinforce concepts. (Formerly PHY 3823. Credit cannot be earned for both PHY 2823 and PHY 3823.) Generally offered: Fall, Spring. Course Fee: LRS1 \$46.20; MEPA \$18; STSI \$21.60; DL01 \$75.

**PHY 3203. Classical Mechanics I. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963 and completion of, with a grade of "C-" or better, or concurrent enrollment in PHY 2823, or consent of instructor. Topics include Newtonian mechanics, oscillations, central-force motion, gravitation, Hamiltonian, and Lagrangian dynamics. Some sections of this course include the use of Mathematica software package as a key component to illustrate and reinforce concepts used in Classical Mechanics. Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 3293. Thermal Physics. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963 and PHY 2823, or consent of instructor. Topics include fundamentals of thermodynamics: entropy, free energy, phase transitions, and thermodynamic potentials; equilibrium, Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac distribution functions; derivation of macroscopic equilibrium thermodynamics from statistical mechanics. Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 3313. Materials Physics. (3-0) 3 Credit Hours.**

Prerequisite: PHY 2103 or consent of instructor. Topics covered include crystal structure and band theory, density functional theory, a survey of properties of metals and semiconductors, phonons, electron-phonon interaction and superconductivity. (Formerly titled "Solid State Physics.") Generally offered: Fall, Spring. This course has Differential Tuition.

**PHY 3343. Physics Research Laboratory. (0-9) 3 Credit Hours.**

Prerequisite: PHY 1971, PHY 2103, and PHY 2111. This course provides students majoring in physics the opportunity to acquire knowledge in advanced experimental techniques gained through actual participation in real-world physics research labs. (Formerly titled "Advanced Physics Laboratory.") Generally offered: Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 3423. Electricity and Magnetism. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963, PHY 2823, and completion of (with a grade of "C-" or better) or concurrent enrollment in MAT 3613, or consent of instructor. Topics include vector calculus, electrostatics, magnetostatics, Faraday's Law, and solutions to Laplace's equation. Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 3443. Modern Optics. (3-0) 3 Credit Hours.**

Prerequisite: PHY 3423 or consent of instructor. Topics include reflection, refraction, absorption, polarization, and diffraction of light, filters, lasers, nonlinear properties, and Fourier optics. Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 3453. Lasers: Theory and Applications. (3-0) 3 Credit Hours.**

Prerequisite: PHY 2103 or consent of instructor. Topics include basic principles and designs of lasers: Einstein A and B coefficients; semiclassical laser theory; the phase-coherent nature of the stimulated emission process; and laser efficiency. Various applications of lasers, such as laser-induced fluorescence, light wave communications, holography, surgery, and laser fusion. This course has Differential Tuition.

**PHY 3513. Electrodynamics. (3-0) 3 Credit Hours.**

Prerequisite: PHY 2823 and PHY 3423, or consent of instructor. Continuation of the material started in PHY 3423. Topics include Maxwell's equations, electromagnetic waves, wave guides, and radiation from accelerated charges. Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 3583. Mathematical Physics II. (3-0) 3 Credit Hours.**

Prerequisite: PHY 2823 or consent of instructor. Topics may include series solutions of differential equations, partial differential equations of physics, special functions, integral transforms and introduction to tensor calculus. Applications may include topics in classical and quantum mechanics, electrostatics and electrodynamics. (Formerly PHY 4823. Credit cannot be earned for both PHY 3583 and PHY 4823.) Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: MEPA \$18; DL01 \$75.

**PHY 3603. Cosmology. (3-0) 3 Credit Hours.**

Prerequisite: PHY 1963 and PHY 2103, or consent of instructor. This course is an introduction to physical cosmology. Topics include large-scale structure, expansion and age of the universe; non-Euclidean spaces, big bang cosmology, baryogenesis, nucleosynthesis, and cosmic microwave background radiation; particle physics and inflationary cosmology. (Formerly PHY 4033. Credit cannot be earned for both PHY 3603 and PHY 4033.) This course has Differential Tuition. Course Fee: MEPA \$18.

**PHY 4013. Relativity: Special and General. (3-0) 3 Credit Hours.**

Prerequisite: PHY 2823 and PHY 3203, or consent of instructor. Topics include special relativity: Lorentz transformations, four-vectors, geometry of flat space-time, relativistic dynamics. General relativity: Principle of equivalence, introduction to tensor calculus, Einstein's field equations, Schwarzschild's solution, black holes. Introduction to cosmology. This course has Differential Tuition.

**PHY 4263. Quantum Mechanics I. (3-0) 3 Credit Hours.**

Prerequisites: PHY 2103, PHY 3203, MAT 2233, and completion of or concurrent enrollment in PHY 3583, or consent of instructor. Topics include the time-independent Schrodinger equation; operator methods, and the postulates of quantum mechanics; one-dimensional potentials; quantum harmonic oscillator; angular momentum and spin; entanglement and its applications; quantum mechanics in three dimensions and the hydrogen atom. Generally offered: Fall, Spring. This course has Differential Tuition. Course fee: DL01 \$75.

**PHY 4423. Quantum Mechanics II. (3-0) 3 Credit Hours.**

Prerequisite: PHY 3583 and PHY 4263, or consent of instructor. Topics include identical particles; time-independent perturbation theory; WKB approximation, time-dependent perturbation theory, the variational principle; the adiabatic approximation and Berry's phase; scattering. Generally offered: Fall, Spring. This course has Differential Tuition. Course Fee: DL01 \$75.

**PHY 4623. Nanotechnology. (3-0) 3 Credit Hours.**

Prerequisite: PHY 2103 or consent of instructor. This course will describe the fundamentals of nanotechnology, including properties of matter at the nanometric size. This course has Differential Tuition.

**PHY 4833. Molecular Biophysics. (3-0) 3 Credit Hours.**

Prerequisites: CHE 1113 and one of the following: PHY 2103, CHE 3804, or CHE 4354 (formerly CHE 3854). Topics include interaction between molecules, principles of thermodynamics (enthalpy, entropy, free energy) applied to biomolecules, Brownian motion and diffusion of molecules, structure of proteins, and principles of quantum mechanics. Biophysical techniques: absorption spectroscopy, transient absorption, fluorescence spectroscopy, fluorescence lifetime, FTIR spectroscopy, linear and circular dichroism, x-ray crystallography, and atomic force microscopy. Generally offered: Spring. This course has Differential Tuition. Course fee: DL01 \$75.

**PHY 4911. Independent Study. (0-0) 1 Credit Hour.**

Prerequisite: Permission in writing (form available) from the instructor, the student's advisor, the Department Chair, and Dean of the College in which the course is offered. Independent reading, research, discussion, and/or writing under the direction of a faculty member. May be repeated for credit, but not more than 6 semester credit hours, regardless of discipline, will apply to a bachelor's degree in physics. This course has Differential Tuition.

**PHY 4913. Independent Study. (0-0) 3 Credit Hours.**

Prerequisite: Permission in writing (form available) from the instructor, the student's advisor, the Department Chair, and Dean of the College in which the course is offered. Independent reading, research, discussion, and/or writing under the direction of a faculty member. May be repeated for credit, but not more than 6 semester credit hours, regardless of discipline, will apply to a bachelor's degree in physics. Generally offered: Spring. This course has Differential Tuition.

**PHY 4953. Special Studies in Physics. (3-0) 3 Credit Hours.**

Prerequisite: Consent of instructor. An organized course offering the opportunity for specialized study not normally or not often available as part of the regular course offerings. Special Studies may be repeated for credit when the topics vary, but not more than 6 semester credit hours, regardless of discipline, will apply to a bachelor's degree. Generally offered: Spring. This course has Differential Tuition. Course fee: DL01 \$75.

**PHY 4983. Unifying Concepts in Physics. (3-0) 3 Credit Hours.**

Prerequisites: PHY 3293, PHY 3513, PHY 4263, and completion with a grade of "C-" or better or concurrent enrollment in PHY 3583, or consent of instructor. This advanced course is designed to help the students develop a more mature and coherent understanding of the whole discipline through an in-depth exploration of the major branches of physics and their theoretical interconnections. Generally offered: Fall. This course has Differential Tuition. Course Fee: MEPA \$18; DL01 \$75.

**PHY 4993. Directed Research. (0-0) 3 Credit Hours.**

Prerequisite: Approval from the instructor, the Department Chair, and the Associate Dean of Undergraduate Studies in the College for which this course is offered; form available on the College of Sciences website. Supervised research mentored by a faculty member engaged in active research within the student's designated area of concentration. Students may produce a thesis in addition to active research. May be repeated. This course can also be used for students pursuing the COS Undergraduate Thesis Option. This course has Differential Tuition.