

# MAJOR IN PHYSICS

The Physics major is divided into three main concentrations designed to give the student the greatest possible flexibility in preparation for graduate study in physics, astrophysics, medicine, engineering or other allied fields, and for professional practice as a physicist in industrial, governmental or institutional laboratories.

In order to provide students a broad and solid base in physics and also to provide the flexibility which enables students to take courses in areas where physics can be applied, all Physics majors take a series of basic physics courses. The first courses are General Physics I, II and III (PHYS 241, PHYS 242 and PHYS 243). They provide an introduction to fundamental classical physics. The junior and senior physics courses treat classical and modern physics in greater depth.

It is recommended that those who intend to pursue graduate studies in physics or astrophysics, take the General Physics Concentration or the Astrophysics Concentration, as well as additional physics electives and mathematics courses. Those who intend to participate in fundamental or applied research and development in industrial or government laboratories are encouraged to take the Applied Physics Concentration and other physics electives.

Students may wish to elect a foreign language as preparation for graduate study. Students may also supplement the program of study by participation in a guided independent study and/or ongoing research project. Up to 6 units of such courses (Independent Study, Directed Readings, Research Problems, etc.) may count toward required physics electives. A combination of well-grounded preparation in fundamentals plus the availability of an individually tailored program of study is designed to optimize students' preparation for graduate school or a professional career. In addition to physics courses, all majors are required to complete courses in mathematics and chemistry. Additional mathematics electives especially recommended are Linear Algebra, Advanced Calculus, Fourier Analysis with Applications, and Numerical Analysis I, II.

Students who intend to major in Physics should contact the department in order to be assigned a faculty adviser. The faculty adviser will assist students in planning a program that will meet their special needs. Advisers are also available for advising on career opportunities and employment. Physics majors are required to complete 16, and minors 8, of the required upper-division units in physics at TU. Students should be aware that most advanced physics courses (300- and 400-level) may be offered in either the first or second term, but not in both terms. Some physics electives are only offered every other year. Advisers will have information on the courses offered and on the schedules.

Most required upper-level physics courses are taught in the late afternoon or early evening on a rotating schedule. This should enable a non-traditional student who can only attend classes at these times to complete the major, although the time required will usually exceed the normal four years. Students should contact the department office or their advisers for information about the scheduling of these courses.

Students must see their advisers no later than the time of their matriculation for the third term in General Physics, which is normally the beginning of the spring term of their sophomore year. Students, after consultation with their advisers, will propose a tentative plan for completing all graduation requirements, including those for the major. This selection of electives for the various concentrations must be

approved by an adviser. The plan may be modified from time to time, but the modification must be approved by the major adviser. Students may also organize an individualized course of studies. This gives students the option to select a plan that reflects their interest in a special area of physics. The array of courses must have internal coherence and be approved by the major adviser.

## Requirements

### Requirements for the Physics Major

All Physics majors must take these required courses (34 units of Physics courses and 8 units of non-Physics courses) in addition to the requirements specified by their chosen concentration or track (see below). All courses that count toward the major must be completed with a grade equivalent of 2.00 or higher.

Code	Title	Units
<b>Required Physics Courses</b>		
PHYS 185	INTRODUCTORY SEMINAR IN PHYSICS	1
Select one of the following sequences:		8
PHYS 241 & PHYS 242	GENERAL PHYSICS I CALCULUS-BASED and GENERAL PHYSICS II CALCULUS-BASED	
PHYS 251 & PHYS 252	HONORS GENERAL PHYSICS I CALCULUS-BASED and HONORS GENERAL PHYSICS II CALCULUS-BASED	
PHYS 243	GENERAL PHYSICS III	4
PHYS 270	COMPUTERS IN PHYSICS	4
PHYS 307	INTRODUCTORY MATHEMATICAL PHYSICS	3
PHYS 311	MODERN PHYSICS I	3
PHYS 341	INTERMEDIATE PHYSICS LABORATORY I	3
PHYS 351	MECHANICS	4
PHYS 354	ELECTRICITY AND MAGNETISM	4
<b>Required Non-Physics Courses</b>		
MATH 273	CALCULUS I	4
MATH 274	CALCULUS II	4
<b>Total Units</b>		<b>42</b>

### General Physics Concentration

The common physics and non-physics requirements must be completed, as well as the following courses. All required courses in this concentration must be completed with a grade equivalent of 2.00 or higher.

Code	Title	Units
<b>Advanced Physics Courses</b>		
PHYS 312	MODERN PHYSICS II	3
PHYS 342	INTERMEDIATE PHYSICS LABORATORY II	3
PHYS 352	THERMODYNAMICS AND KINETIC THEORY	3
PHYS 385	PHYSICS SEMINAR	1
PHYS 455	INTRODUCTORY QUANTUM MECHANICS	3
PHYS 486	PHYSICS SEMINAR II	1
<b>Non-Physics Courses</b>		
CHEM 131 & 131L	GENERAL CHEMISTRY I LECTURE and GENERAL CHEMISTRY I LABORATORY	4

COSC 175	GEN COMPUTER SCI	4
MATH 275	CALCULUS III	4
MATH 374	DIFFERENTIAL EQUATIONS	3
<b>Physics/Astrophysics Upper-Level Electives <sup>1</sup></b>		<b>9</b>
ASTR 452	HIGH ENERGY ASTROPHYSICS	
PHYS 335	BASIC ELECTRONICS	
PHYS 337	DIGITAL ELECTRONICS	
PHYS 361	OPTICS FUNDAMENTALS	
PHYS 411	GRAVITATION, RELATIVITY, AND COSMOLOGY	
PHYS 457	SOLID STATE PHYSICS	
PHYS 458	MAGNETISM AND MAGNETIC MATERIALS	
PHYS 459	NUCLEAR AND PARTICLE PHYSICS	
<b>Total Units</b>		<b>38</b>

<sup>1</sup> A full list of allowed PHYS and ASTR electives for the concentration can be found on the Physics Department website. A maximum of 3 units may be fulfilled with independent-format courses.

## Applied Physics Concentration

The common physics and non-physics requirements must be completed, as well as the following courses. All required courses in this concentration must be completed with a grade equivalent of 2.00 or higher.

Code	Title	Units
<b>Advanced Physics Courses</b>		
PHYS 312	MODERN PHYSICS II	3
PHYS 335	BASIC ELECTRONICS	4
or PHYS 337	DIGITAL ELECTRONICS	
PHYS 342	INTERMEDIATE PHYSICS LABORATORY II	3
PHYS 361	OPTICS FUNDAMENTALS	4
PHYS 385	PHYSICS SEMINAR	1
PHYS 486	PHYSICS SEMINAR II	1
<b>Non-Physics Courses</b>		
CHEM 131 & 131L	GENERAL CHEMISTRY I LECTURE and GENERAL CHEMISTRY I LABORATORY	4
COSC 175	GEN COMPUTER SCI	4
MATH 275	CALCULUS III	4
MATH 374	DIFFERENTIAL EQUATIONS	3
<b>Physics/Astrophysics Upper-Level Electives <sup>1</sup></b>		<b>9</b>
PHYS 335	BASIC ELECTRONICS (whichever course not selected as required)	
or PHYS 337	DIGITAL ELECTRONICS	
PHYS 352	THERMODYNAMICS AND KINETIC THEORY	
PHYS 455	INTRODUCTORY QUANTUM MECHANICS	
PHYS 457	SOLID STATE PHYSICS	
PHYS 458	MAGNETISM AND MAGNETIC MATERIALS	
<b>Total Units</b>		<b>40</b>

<sup>1</sup> A full list of allowed PHYS and ASTR electives for the concentration can be found on the Physics Department website. A maximum of 3 units may be fulfilled with independent-format courses.

## Astrophysics Concentration

The common physics and non-physics requirements must be completed, as well as the following courses. All required courses in this concentration must be completed with a grade equivalent of 2.00 or higher.

Code	Title	Units
<b>Physics and Astrophysics Courses</b>		
ASTR 261	INTRODUCTION TO ASTROPHYSICS	4
ASTR 303	ASTROPHYSICAL TECHNIQUES	3
ASTR 331	STELLAR ASTROPHYSICS	3
ASTR 385	ASTROPHYSICS SEMINAR	1
ASTR 432	GALAXIES AND COSMOLOGY	3
PHYS 312	MODERN PHYSICS II	3
PHYS 486	PHYSICS SEMINAR II	1
<b>Non-Physics Courses</b>		
CHEM 131 & 131L	GENERAL CHEMISTRY I LECTURE and GENERAL CHEMISTRY I LABORATORY	4
COSC 175	GEN COMPUTER SCI	4
MATH 275	CALCULUS III	4
MATH 374	DIFFERENTIAL EQUATIONS	3
<b>Physics/Astrophysics Upper-Level Electives <sup>1</sup></b>		<b>6</b>
ASTR 371	PLANETARY ASTRONOMY	
ASTR 452	HIGH ENERGY ASTROPHYSICS	
PHYS 335	BASIC ELECTRONICS	
PHYS 337	DIGITAL ELECTRONICS	
PHYS 352	THERMODYNAMICS AND KINETIC THEORY	
PHYS 361	OPTICS FUNDAMENTALS	
PHYS 411	GRAVITATION, RELATIVITY, AND COSMOLOGY	
PHYS 455	INTRODUCTORY QUANTUM MECHANICS	
PHYS 459	NUCLEAR AND PARTICLE PHYSICS	
<b>Total Units</b>		<b>39</b>

<sup>1</sup> A full list of allowed PHYS and ASTR electives for the concentration can be found on the Physics Department website. A maximum of 3 units may be fulfilled with independent-format courses.

## Computational Physics Concentration

The common physics and non-physics requirements must be completed, as well as the following courses. All required courses in this concentration must be completed with a grade equivalent of 2.00 or higher.

Code	Title	Units
<b>Advanced Physics Courses</b>		
PHYS 337	DIGITAL ELECTRONICS	4
PHYS 385	PHYSICS SEMINAR	1
PHYS 486	PHYSICS SEMINAR II	1
<b>Non-Physics Courses</b>		
COSC 236	INTRODUCTION TO COMPUTER SCIENCE I	4
COSC 237	INTRODUCTION TO COMPUTER SCIENCE II	4
COSC 290	PRINCIPLES OF COMPUTER ORGANIZATION	4

COSC 336	DATA STRUCTURES AND ALGORITHM ANALYSIS	4
MATH 263	DISCRETE MATHEMATICS	3
MATH 265	ELEMENTARY LINEAR ALGEBRA	4
MATH 275	CALCULUS III	4
MATH 374	DIFFERENTIAL EQUATIONS	3
MATH 435	NUMERICAL ANALYSIS I	3
<b>Total Units</b>		<b>39</b>

## Engineering Dual Degree Track

This track is only available to those students participating in the Dual Degree Program. The common physics and non-physics requirements must be completed, as well as the following courses. All required courses in this track must be completed with a grade equivalent of 2.00 or higher. Please see the Department of Physics, Astronomy and Geosciences for further details.

Code	Title	Units
<b>Advanced Physics Courses</b>		
PHYS 385	PHYSICS SEMINAR	1
Minimum two upper (300-400) level engineering courses		6
<b>Non-Physics Courses</b>		
CHEM 131 & 131L	GENERAL CHEMISTRY I LECTURE and GENERAL CHEMISTRY I LABORATORY	4
CHEM 132 & 132L	GENERAL CHEMISTRY II LECTURE and GENERAL CHEMISTRY II LABORATORY	4
MATH 275	CALCULUS III	4
MATH 374	DIFFERENTIAL EQUATIONS	3
<b>Total Units</b>		<b>22</b>

## Four-Year Plan of Study

By its very nature, physics is more hierarchical in its course structure than typical humanities or social science disciplines. Therefore, many courses depend heavily on prerequisite courses (such as calculus and general physics). Any time that is required to prepare for calculus, such as taking MATH 119, must be added to the four-year minimum. Normally, progress in mathematics and general physics is the pacesetter.

## General Concentration in Physics Suggested Four-Year Plan

Based on course availability and student needs and preferences, the selected sequences will probably vary from those presented below. Students should consult with their adviser to make the most appropriate elective choices.

<b>Freshman</b>		
Term 1	Units Term 2	Units
CHEM 131 & 131L (Core 7)	4 CHEM 132 & 132L	4
MATH 273 (Core 3)	4 MATH 274	4
PHYS 185	1 PHYS 241 or 251 (Core 8)	4
Core 1 (or Core 2)	3 Core 2 (or Core 1)	3
Core 4	3	
	<b>15</b>	<b>15</b>

<b>Sophomore</b>		
Term 1	Units Term 2	Units
MATH 275	4 MATH 374	3
PHYS 242 or 252	4 PHYS 243	4
Core 5	3 PHYS 270	4
Core 6	3 PHYS 307	3
	<b>14</b>	<b>14</b>

<b>Junior</b>		
Term 1	Units Term 2	Units
PHYS 311	3 PHYS 312	3
PHYS 341	3 PHYS 342	3
PHYS 351	4 PHYS 354	4
Core 9	3 PHYS 385	1
Core 10	3 Core 11	3
	Core 12	3
	<b>16</b>	<b>17</b>

<b>Senior</b>		
Term 1	Units Term 2	Units
PHYS 455	3 PHYS 352	3
PHYS 486	1 PHYS Elective	3
PHYS Elective	3 PHYS Elective	3
Core 13	3 Core 14	3
Elective	3 Elective	1
Elective	3	
	<b>16</b>	<b>13</b>

**Total Units 120**

## Applied Concentration in Physics Suggested Four-Year Plan

Based on course availability and student needs and preferences, the selected sequences will probably vary from those presented below. Students should consult with their adviser to make the most appropriate elective choices.

<b>Freshman</b>		
Term 1	Units Term 2	Units
CHEM 131 & 131L (Core 7)	4 CHEM 132 & 132L (Core 8)	4
MATH 273 (Core 3)	4 MATH 274	4
PHYS 185	1 PHYS 241 or 251	4
Core 1 (or Core 2)	3 Core 2 (or Core 1)	3
Core 4	3	
	<b>15</b>	<b>15</b>

<b>Sophomore</b>		
Term 1	Units Term 2	Units
MATH 275	4 MATH 374	3
PHYS 242 or 252	4 PHYS 243	4
Core 5	3 PHYS 270	4
Core 6	3 PHYS 307	3
	<b>14</b>	<b>14</b>
<b>Junior</b>		
Term 1	Units Term 2	Units
PHYS 311	3 PHYS 312	3

PHYS 341	3	PHYS 342	3
PHYS 351	4	PHYS 354	4
Core 9	1	PHYS 385	1
Core 10	3	Core 12	3
	3	Core 13	3
	<b>16</b>		<b>17</b>

Senior			
Term 1	Units	Term 2	Units
PHYS 361	4	PHYS 335 or 337	4
PHYS 486	3	PHYS Elective	3
PHYS Elective	3	PHYS Elective	3
Core 14	3	Core 11	3
Elective	2	Elective	2
	<b>14</b>		<b>15</b>

Total Units 120

## Astrophysics Concentration Suggested Four-Year Plan

Based on course availability and student needs and preferences, the selected sequences will probably vary from those presented below. Students should consult with their adviser to make the most appropriate elective choices.

Freshman			
Term 1	Units	Term 2	Units
MATH 273 (Core 3)	4	MATH 274	4
PHYS 185	4	PHYS 242 or 252 (Core 8)	4
PHYS 241 or 251 (Core 7)	4	PHYS 270	4
Core 1 (or Core 2)	3	Core 2 (or Core 1)	3
Core 4	3		
	<b>15</b>		<b>15</b>

Sophomore			
Term 1	Units	Term 2	Units
ASTR 261	4	PHYS 243	4
MATH 275	3	PHYS 312	3
PHYS 311	3	Core 5	3
PHYS 341	3	Elective	3
	<b>14</b>		<b>13</b>

Junior			
Term 1	Units	Term 2	Units
CHEM 131 & 131L	3	ASTR 303	3
MATH 374	3	ASTR 331	3
Core 6	1	ASTR 385	1
Core 9	4	CHEM 132 & 132L	4
Core 10	3	PHYS 307	3
	<b>16</b>		<b>14</b>

Senior			
Term 1	Units	Term 2	Units
ASTR 432	4	PHYS 354	4
PHYS 351	3	PHYS Elective	3
PHYS 486	3	Core 12	3

PHYS Elective	3	Core 13	3
Core 11	3	Core 14	3
Elective	3		
	<b>17</b>		<b>16</b>

Total Units 120

## Computational Physics Concentration Suggested Four-Year Plan

Based on course availability and student needs and preferences, the selected sequences will probably vary from those presented below. Students should consult with their adviser to make the most appropriate elective choices.

Freshman			
Term 1	Units	Term 2	Units
MATH 273 (Core 3)	4	COSC 236	4
PHYS 185	4	MATH 274	4
PHYS 241 or 251 (Core 7)	4	PHYS 242 or 252 (Core 8)	4
Core 1 (or Core 2)	3	PHYS 270	4
Core 4	3		
	<b>15</b>		<b>16</b>

Sophomore			
Term 1	Units	Term 2	Units
COSC 237	3	MATH 263	3
MATH 275	3	MATH 374	3
PHYS 311	4	PHYS 243	4
PHYS 341	3	PHYS 307	3
Core 2 (or Core 1)	3	Core 5	3
	<b>17</b>		<b>16</b>

Junior			
Term 1	Units	Term 2	Units
COSC 290	4	COSC 336	4
MATH 265	4	PHYS 354	4
PHYS 351	1	PHYS 385	1
Core 6	3	Core 9	3
	3	Core 10	3
	<b>15</b>		<b>15</b>

Senior			
Term 1	Units	Term 2	Units
MATH 435	3	Elective	3
PHYS 337	3	Elective	3
PHYS 486	3	Core 13	3
Core 11	3	Core 14	3
Core 12	3		
	<b>14</b>		<b>12</b>

Total Units 120

## Learning Outcomes

- Demonstrate an understanding of fundamental principles of physics and major concepts in a student's chosen track and be able to apply these principles to solve quantitative problems.
- Demonstrate an understanding of the nature of scientific research.

- c. Communicate scientific information effectively in both oral and written formats.
- d. Utilize and apply technology to investigate experimental and theoretical scientific problems.