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 [or PHYS 251], PHYS 242 [or PHYS 252] and PHYS 243). They provide an introduction to both classical and modern 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 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. In addition the Core Curriculum requirements must be completed.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 185</td>
<td>INTRODUCTORY HONORS SEMINAR IN PHYSICS</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Select one of the following:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PHYS 241 &amp; PHYS 242</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>GENERAL PHYSICS I CALCULUS-BASED</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and GENERAL PHYSICS II CALCULUS-BASED</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PHYS 251 &amp; PHYS 252</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HONORS GENERAL PHYSICS I CALCULUS-BASED</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and HONORS GENERAL PHYSICS II CALCULUS-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BASED</td>
<td></td>
</tr>
<tr>
<td>PHYS 243</td>
<td>GENERAL PHYSICS III</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 270</td>
<td>COMPUTERS IN PHYSICS</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 307</td>
<td>INTRODUCTORY MATHEMATICAL PHYSICS</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 311</td>
<td>MODERN PHYSICS I</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 341</td>
<td>INTERMEDIATE PHYSICS LABORATORY I</td>
<td>3</td>
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<tr>
<td>PHYS 351</td>
<td>MECHANICS</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 354</td>
<td>ELECTRICITY &amp; MAGNETISM</td>
<td>4</td>
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<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 273</td>
<td>CALCULUS I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 274</td>
<td>CALCULUS II</td>
<td>4</td>
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</table>

Total Units 42

General Physics Concentration

The common physics courses and the 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.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 312</td>
<td>MODERN PHYSICS II</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 342</td>
<td>INTERMEDIATE PHYSICS LABORATORY II</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 352</td>
<td>THERMODYNAMICS AND KINETIC THEORY</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 385</td>
<td>PHYSICS SEMINAR</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 455</td>
<td>INTRODUCTORY QUANTUM MECHANICS</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 486</td>
<td>PHYSICS SEMINAR II</td>
<td>1</td>
</tr>
</tbody>
</table>

At least nine units of upper level physics or astronomy electives

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 131</td>
<td>GENERAL CHEMISTRY I LECTURE</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 131L</td>
<td>GENERAL CHEMISTRY I LABORATORY</td>
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<td>CHEM 132</td>
<td>GENERAL CHEMISTRY II LECTURE</td>
<td>3</td>
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</tbody>
</table>
CHEM 132L  GENERAL CHEMISTRY II LABORATORY  1
MATH 275  CALCULUS III  4
MATH 374  DIFFERENTIAL EQUATIONS  3

Total Units  38

**Applied Physics Concentration**

The common physics courses and the 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.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
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<td>MODERN PHYSICS II</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 335</td>
<td>BASIC ELECTRONICS</td>
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<tr>
<td>or PHYS 337</td>
<td>DIGITAL ELECTRONICS</td>
<td></td>
</tr>
<tr>
<td>PHYS 342</td>
<td>INTERMEDIATE PHYSICS LABORATORY II</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 361</td>
<td>OPTICS FUNDAMENTALS</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 385</td>
<td>PHYSICS SEMINAR</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 486</td>
<td>PHYSICS SEMINAR II</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>At least nine units of upper level physics or astronomy electives</td>
<td>9</td>
</tr>
<tr>
<td>CHEM 131</td>
<td>GENERAL CHEMISTRY I LECTURE</td>
<td>3</td>
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<tr>
<td>CHEM 131L</td>
<td>GENERAL CHEMISTRY I LABORATORY</td>
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<td>CHEM 132</td>
<td>GENERAL CHEMISTRY II LECTURE</td>
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</tr>
<tr>
<td>CHEM 132L</td>
<td>GENERAL CHEMISTRY II LABORATORY</td>
<td>1</td>
</tr>
<tr>
<td>MATH 275</td>
<td>CALCULUS III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 374</td>
<td>DIFFERENTIAL EQUATIONS</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Units  40

**Astrophysics Concentration**

The common physics and non-physics required courses 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.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>ASTR 161</td>
<td>THE SKY AND THE SOLAR SYSTEM</td>
<td>4</td>
</tr>
<tr>
<td>ASTR 181</td>
<td>STARS, GALAXIES, AND THE EARLY UNIVERSE</td>
<td>4</td>
</tr>
<tr>
<td>ASTR 303</td>
<td>ASTROPHYSICAL TECHNIQUES</td>
<td>3</td>
</tr>
<tr>
<td>ASTR 331</td>
<td>INTRODUCTION TO STELLAR ASTROPHYSICS</td>
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</tr>
<tr>
<td>ASTR 385</td>
<td>ASTROPHYSICS SEMINAR</td>
<td>1</td>
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<tr>
<td>ASTR 432</td>
<td>GALAXIES AND COSMOLOGY</td>
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<td></td>
<td>At least six units of upper level physics or astronomy electives</td>
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<td>CHEM 132</td>
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<tr>
<td>CHEM 132L</td>
<td>GENERAL CHEMISTRY II LABORATORY</td>
<td>1</td>
</tr>
<tr>
<td>MATH 275</td>
<td>CALCULUS III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 374</td>
<td>DIFFERENTIAL EQUATIONS</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Units  40

**Computational Physics Concentration**

The common physics and non-physics required courses 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.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 374</td>
<td>DIFFERENTIAL EQUATIONS</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Units  43

**Engineering Dual Degree Track**

This track is only available to those students participating in the Dual Degree Program. The common physics and non-physics required courses 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 Department for further details.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 385</td>
<td>PHYSICS SEMINAR</td>
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</tbody>
</table>

Two upper level engineering courses  6

**Advanced Physics Courses**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
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<tbody>
<tr>
<td>PHYS 377</td>
<td>DIGITAL ELECTRONICS</td>
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<tr>
<td>PHYS 385</td>
<td>PHYSICS SEMINAR</td>
<td>1</td>
</tr>
<tr>
<td>PHYS 486</td>
<td>PHYSICS SEMINAR II</td>
<td>1</td>
</tr>
</tbody>
</table>

**Non-Physics Requirements**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>CHEM 131</td>
<td>GENERAL CHEMISTRY I LECTURE</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 131L</td>
<td>GENERAL CHEMISTRY I LABORATORY</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 132</td>
<td>GENERAL CHEMISTRY II LECTURE</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 132L</td>
<td>GENERAL CHEMISTRY II LABORATORY</td>
<td>1</td>
</tr>
<tr>
<td>MATH 275</td>
<td>CALCULUS III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 374</td>
<td>DIFFERENTIAL EQUATIONS</td>
<td>3</td>
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</tbody>
</table>

Total Units  22

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.

**Freshman**

<table>
<thead>
<tr>
<th>Term 1</th>
<th>Units Term 2</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 131 &amp; 131L (Core 7)</td>
<td>4 CHEM 132 &amp; 132L</td>
<td>4</td>
</tr>
<tr>
<td>MATH 273 (Core 3)</td>
<td>4 MATH 274</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 185</td>
<td>1 PHYS 241 or 251 (Core 8)</td>
<td>4</td>
</tr>
<tr>
<td>Core 1 (or Core 2)</td>
<td>3 Core 2 (or Core 1)</td>
<td>3</td>
</tr>
<tr>
<td>Core 4</td>
<td>3</td>
<td>15</td>
</tr>
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</table>

**Sophomore**

<table>
<thead>
<tr>
<th>Term 1</th>
<th>Units Term 2</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 275</td>
<td>4 MATH 374</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 242 or 252</td>
<td>4 PHYS 243</td>
<td>4</td>
</tr>
<tr>
<td>Core 5</td>
<td>3 PHYS 270</td>
<td>4</td>
</tr>
<tr>
<td>Core 6</td>
<td>3 PHYS 307</td>
<td>3</td>
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</table>

**Junior**

<table>
<thead>
<tr>
<th>Term 1</th>
<th>Units Term 2</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 311</td>
<td>3 PHYS 312</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 341</td>
<td>3 PHYS 342</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 351</td>
<td>4 PHYS 354</td>
<td>4</td>
</tr>
<tr>
<td>Core 9</td>
<td>3 PHYS 385</td>
<td>1</td>
</tr>
<tr>
<td>Core 10</td>
<td>3 Core 11</td>
<td>3</td>
</tr>
<tr>
<td>Core 12</td>
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**Senior**

<table>
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<tr>
<th>Term 1</th>
<th>Units Term 2</th>
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</thead>
<tbody>
<tr>
<td>PHYS 455</td>
<td>3 PHYS 352</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 486</td>
<td>1 PHYS Elective</td>
<td>3</td>
</tr>
<tr>
<td>PHYS Elective</td>
<td>3 PHYS Elective</td>
<td>3</td>
</tr>
<tr>
<td>Core 13</td>
<td>3 Core 14</td>
<td>3</td>
</tr>
<tr>
<td>Elective</td>
<td>3 Elective</td>
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</tr>
<tr>
<td>Elective</td>
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<td>16</td>
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</table>

**Total Units 122**

## 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**

<table>
<thead>
<tr>
<th>Term 1</th>
<th>Units Term 2</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 131 &amp; 131L (Core 7)</td>
<td>4 CHEM 132 &amp; 132L</td>
<td>4</td>
</tr>
<tr>
<td>MATH 273 (Core 3)</td>
<td>4 MATH 274</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 185</td>
<td>1 PHYS 241 or 251 (Core 8)</td>
<td>4</td>
</tr>
<tr>
<td>Core 1 (or Core 2)</td>
<td>3 Core 2 (or Core 1)</td>
<td>3</td>
</tr>
<tr>
<td>Core 4</td>
<td>3</td>
<td>15</td>
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</table>

**Sophomore**

<table>
<thead>
<tr>
<th>Term 1</th>
<th>Units Term 2</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 275</td>
<td>4 MATH 374</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 242 or 252</td>
<td>4 PHYS 243</td>
<td>4</td>
</tr>
<tr>
<td>Core 5</td>
<td>3 PHYS 270</td>
<td>4</td>
</tr>
<tr>
<td>Core 6</td>
<td>3 PHYS 307</td>
<td>3</td>
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</table>

**Junior**

<table>
<thead>
<tr>
<th>Term 1</th>
<th>Units Term 2</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 311</td>
<td>3 PHYS 312</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 341</td>
<td>3 PHYS 342</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 351</td>
<td>4 PHYS 354</td>
<td>4</td>
</tr>
<tr>
<td>Core 9</td>
<td>3 PHYS 385</td>
<td>1</td>
</tr>
<tr>
<td>Core 10</td>
<td>3 Core 12</td>
<td>3</td>
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**Senior**

<table>
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<tr>
<th>Term 1</th>
<th>Units Term 2</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 361</td>
<td>4 PHYS 335 or 337</td>
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</tr>
<tr>
<td>PHYS 486</td>
<td>1 PHYS Elective</td>
<td>3</td>
</tr>
<tr>
<td>PHYS Elective</td>
<td>3 PHYS Elective</td>
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</tr>
<tr>
<td>Core 14</td>
<td>3 Core 11</td>
<td>3</td>
</tr>
<tr>
<td>Elective</td>
<td>3 Elective</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total Units 121**

## 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.

**Freshman**

<table>
<thead>
<tr>
<th>Term 1</th>
<th>Units Term 2</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 273 (Core 3)</td>
<td>4 MATH 274</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 185</td>
<td>1 PHYS 241 or 251 (Core 8)</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 241 or 251 (Core 7)</td>
<td>4 PHYS 270</td>
<td>4</td>
</tr>
<tr>
<td>Core 1 (or Core 2)</td>
<td>3 Core 2 (or Core 1)</td>
<td>3</td>
</tr>
<tr>
<td>Core 4</td>
<td>3</td>
<td>15</td>
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</table>

**Sophomore**

<table>
<thead>
<tr>
<th>Term 1</th>
<th>Units Term 2</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTR 161</td>
<td>4 ASTR 181</td>
<td>4</td>
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</table>

**Total Units 122**
### 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**

<table>
<thead>
<tr>
<th>Term 1</th>
<th>Units Term 2</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 273 (Core 3)</td>
<td>4 COSC 236</td>
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<td>PHYS 185</td>
<td>1 MATH 274</td>
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<td>PHYS 241 or 251 (Core 7)</td>
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<td>Core 1 (or Core 2)</td>
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**Sophomore**

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<td>COSC 237</td>
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<td>MATH 275</td>
<td>4 MATH 374</td>
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<td>PHYS 341</td>
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<td>Core 2 (or Core 1)</td>
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**Junior**

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<td>MATH 265</td>
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<td>PHYS 351</td>
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**Senior**

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<td>PHYS 337</td>
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<tr>
<td>PHYS 486</td>
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<td>Core 11</td>
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Total Units 120

1. 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.
2. Demonstrate an understanding of the nature of scientific research.
3. Communicate scientific information effectively in both oral and written formats.
4. Utilize and apply technology to investigate experimental and theoretical scientific problems.