

Undergraduate Program in Physics & Astronomy  
Stony Brook University

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# Chapter 1

## Introduction

The Department of Physics & Astronomy at Stony Brook University is one of the top Physics departments in the country as well as a nationally recognized program in Astronomy. Our research activities span a broad range, and are at the forefront of their fields, giving our students great opportunities for study. Our own facilities are complemented by the unique resources available at nearby Brookhaven National Laboratory. Recent external rankings<sup>1</sup> of the department are available.

Why study Physics or Astronomy? Physics considers the most fundamental forces of nature, and applies the knowledge gained to obtain detailed understanding of complex systems. Astronomy seeks to understand the structure and evolution of the Universe on all scales. In both cases, asking good questions of our understanding of nature often leads to unexpected discoveries. The study of radioactivity eventually led to an understanding of supernovae (when stars explode), and the study of atomic spectroscopy led to the development of the laser and the discovery of the Universe's expansion.

At the introductory level, the study of these disciplines serves to demystify our technological world both by explaining the basic ideas behind many technologies, and by introducing the scientific process (quantified critical thinking). Further study leading to a Minor, Bachelor of Science Degree, or Bachelor of Arts degree, teaches one classical and quantum physics and how to test theories against reality in the laboratory; this training in independent thinking is valuable for further studies in science, and also in other walks of life.

This guide is intended to provide an explanation of the undergraduate program in Physics (see Chap. 2), specific courses (see Sec. 2.9), and to provide various resources (see Chap. 4) such as whom to contact with questions, information on careers (see Sec. 4.9), and so on. Information specific to the undergraduate program in astronomy is located on a separate web site<sup>2</sup>.

This document is available both as a web page at

<http://www.astro.sunysb.edu/dugs/ug/ug/index.html>

and as an Adobe Acrobat file at

<http://www.astro.sunysb.edu/dugs/ug/ug.pdf>

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<sup>1</sup><http://insti.physics.sunysb.edu/physics/rankings.htm>

<sup>2</sup><http://www.astro.sunysb.edu/astro/UGProgram/index.html>

## Chapter 2

# The undergraduate program

The Undergraduate Bulletin<sup>1</sup> provides official information on graduation requirements for various degree programs at Stony Brook. We highlight here programs specific to Physics & Astronomy.

### 2.1 Introductory physics courses

The following courses are intended for non-science majors, but may be of interest to anyone:

- PHY 112 (Light, Color and Vision; DEC E, no prerequisites)
- PHY 113 (Physics of Sports; DEC E, no prerequisite)
- PHY 114 (Electromagnetism, Waves and Radiation for Sports Science; DEC E, PHY 113 as prerequisite)
- PHY 119 (Physics for Environmental Studies; DEC E, no prerequisites)
- PHY 313/CEN 544 (Mystery of Matter; DEC H)
- PHY 315/CEB 558 (Cosmic Rays: Experimental Research for Non-Physics Majors; DEC E)

The following courses are intended for life science students:

- PHY 121/ 122 (Physics for the Life Sciences I and II) is a set of courses designed especially for biology and pre-medical students. These courses present the fundamentals of physics in the context of biological applications. Note the lab sections for these courses are listed as 123 and 124. *Note: the PHY 121/122 sequence has calculus as a pre-requisite; students attempting to gain credit for PHY 121/122 via transfer credits from other colleges or universities are advised to look at Sec. 2.12.*

The following courses are intended for natural science and engineering majors, including Physics and Astronomy majors:

- PHY 125/126/127(Classical Physics A, B, and C). Note that you can take these in either order: PHY 125/126/127 or PHY 125/127/126.
- PHY 131/ 132 (Classical Physics I and II) covers the same material as the three-semester PHY 125/126/127 sequence but at a more rapid pace. Note: the lab sections for these courses are listed as 133 and 134.
- PHY 141/142(Classical Physics I and II Honors) covers the material of PHY 131/132 in greater depth.

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<sup>1</sup><http://www.stonybrook.edu/ugrdbulletin/current/>

## 2.2 Bachelor of Science in Physics

For the Bachelor of Science degree in Physics, the official requirements are listed in the undergraduate bulletin<sup>2</sup>, but we summarize them here for informational purposes. Completion of the major requires approximately 49 credits in Physics and physics related courses, and 14 credits in Mathematics. Note that completion of the Diversified Education Curriculum or DEC requirements other than C (Mathematical and Statistical Reasoning) and E (Natural Science) requires about 36 credits. Students thus have 20 credits or more to “play with” beyond completing university and Physics B.S. requirements if students take the minimum of 120 credits for their degree. Up to three courses at the 100 – 200 level passed with a C- may be applied to the major; all others including upper division courses must be passed with a letter grade of C or higher.

The following Physics courses are required for the Physics B.S. degree:

- PHY 131, 132 Classical Physics I, II (note that the PHY 125, 126, 127 sequence, or the 141, 142 sequence, are also acceptable).
- PHY 251/252 Modern Physics plus laboratory
- PHY 277 (AST 277) Computation for Physics and Astronomy
- PHY 300 Waves and Optics
- PHY 301 Electromagnetic Theory I
- PHY 303 Mechanics
- PHY 306 Thermodynamics, Kinetic Theory, and Statistical Mechanics
- PHY 308 Quantum Physics
- PHY 335 Electronics and Instrumentation Laboratory
- PHY 445 Senior Laboratory I

At least four courses numbered 300 or higher submitted for the major must be taken at Stony Brook.

The following Mathematics courses are required for the Physics B.S. degree:

- One of the following sequences: MAT 131, 132 (Calculus I, II) or MAT 141, 142 (Honors Calculus I, II) or MAT 125, 126, 127 (Calculus A, B, C)
- One of the following: MAT 205 (Calculus III), or MAT 203 (Calculus III with Applications), or AMS 261 (Applied Calculus III). Note that MAT 205 has MAT 211 or AMS 210 (linear algebra) as a pre-requisite, but this is a course strongly recommended for research-oriented physics majors anyway.
- One of the following: MAT 305 (Calculus IV), or MAT 303 (Calculus IV with Applications), or AMS 361 (Applied Calculus IV: Differential Equations)

Equivalency for MAT courses achieved on the Mathematics Placement Examination is accepted as fulfillment of the corresponding requirements without the necessity of substituting other credits. Students must also complete twelve credits of approved physics-related courses (see Sec. 2.10) that complement a physics major’s education.

### 2.2.1 Upper-Division Writing Requirement

Students are certified as satisfying their Upper-Division Writing Requirement by completing a writing project within their major. Whether one works in research or in industry, clear and effective written communication is incredibly important. Physicists and Astronomers are called upon to effectively and succinctly communicate their research results in journal publications, and also to convey the importance of their research goals and their plan for achieving them in funding applications (whether for Federal or private research funds, or for internal R&D funds in industry). Students in the senior laboratory course will gain experience in standard technical communication of the sort used in research papers and posters, and this will be reflected in their obtaining a passing grade for the course. To meet the Upper-Division Writing Requirement for the B.S. in Physics, something beyond this terse form of writing of experimental results is required. Examples of how this can be achieved include:

<sup>2</sup><http://www.stonybrook.edu/ugrdbulletin/current/pdfs/phyM.pdf>

- Students may choose a lab experiment from a PHY 300 or 400 level course and elaborate upon it by providing an extended introduction (for example, 5-8 pages) of the history and significance of the experiment. Proper citations to the original papers should be included.
- Students who are involved in a research project could use that as the basis for writing a 10-15 page “mock” research funding proposal, describing the background and significance of the project, prior work in the area, and goals of the proposed research and a plan to reach those goals.

Each student must attempt to pass this requirement before the end of the junior year. They should communicate with the course instructor or research supervisor of their intent to use the course or project to meet their Upper-Division Writing Requirement within the first month of the semester. If there are questions over the suitability of the proposed writing project, they should be discussed with the undergraduate program director. Students are encouraged to seek comments on a draft of their text during the course of the semester, and the final text should be turned in by the last day of classes that semester. The course instructor or research supervisor will then carefully read the paper and forward the paper and their recommendation to the undergraduate program director for consideration; the undergraduate program director makes the final determination. The satisfaction of the writing requirement is certified independently of the course grade.

Note that students who are double-majors in Physics and in Astronomy have the option of satisfying *either* major’s writing requirement; they do not have to do it twice. The Astronomy upper-division writing requirement is described in Sec. 2.4.1.

## 2.2.2 Honors

To receive the Bachelor of Science in Physics with Honors, in addition to the courses required for the major, a student must take PHY487 (for at least three credits) and two additional 400 level courses, achieving an overall grade point average in the courses numbered 300 or higher of at least 3.30.

## 2.3 Bachelor of Science in Physics with a Specialization in Optics

The department also offers a Bachelor of Science degree in Physics with a specialization in Optics. In addition to the completing all the requirements of the Physics major, the specialization requires an additional 12 credits with a grade of C or higher, including:

Required departmental courses:

- PHY 302 Electromagnetic Theory II
- PHY 452 Lasers

Optics-related laboratory experience:

- PHY 487 Research (at least 3 credits, optics related)

One additional elective course:

- Either PHY 405 Quantum Mechanics II, or
- One of many optics related courses in other departments including the College of Engineering and Applied Sciences. Advanced approval of such courses must be obtained from the Director of Undergraduate Studies. Examples of such courses in CEAS include: ESE 341 Communication Theory, ESE 357 Digital Image Processing, EXE 358 Computer Vision, ESE 362 Opto-electronic Devices, ESE 363 Fiberoptic Communications, and ESM 325 Diffraction Techniques.

Completion of the Optics specialization will be noted on the official transcript and the degree. The additional courses required of the specialization, if appropriate, may also be used toward graduating with departmental Honors.

## 2.4 Bachelor of Science in Astronomy

For the Bachelor of Science degree in Astronomy, the official requirements are listed in the undergraduate bulletin<sup>3</sup>. The Astronomy program is also described in more detail on a separate web page<sup>4</sup>; we summarize some of the information here.

The following Astronomy courses are required for the Astronomy B.S. degree:

- AST 203 Astronomy
- AST 277 (PHY 277) Computation for Physics and Astronomy
- AST 341 Stars and Radiation
- AST 346 Galaxies
- AST 347 Cosmology
- At least six credits from additional AST courses numbered 200 or higher (except AST 248, 301, 304 and 475). Up to three credits of AST 287, 447, and 487 may be used toward this requirement.

The following Physics courses are required for the Astronomy B.S. degree:

- PHY 131/133, 132/134 Classical Physics I, II and labs (note that the PHY 125, 126, 127 sequence, or the 141, 142 sequence, are also acceptable).
- PHY 251/252 Modern Physics with Laboratory
- PHY 300 Waves and Optics
- PHY 306 Thermodynamics, Kinetic Theory, and Statistical Mechanics
- At least 8 credits of advanced physics-related courses (see Sec. 2.11).

The following Mathematics courses are required for the Astronomy B.S. degree:

- One of the following sequences: MAT 131, 132 (Calculus I, II) or MAT 141, 142 (Honors Calculus I, II) or MAT 125, 126, 127 (Calculus A, B, C)
- One of the following: MAT 205 (Calculus III), or MAT 203 (Calculus III with Applications), or AMS 261 (Applied Calculus III). Note that MAT 205 has MAT 211 or AMS 210 (linear algebra) as a pre-requisite, but this is a course strongly recommended for research-oriented astronomy majors anyway.
- One of the following: MAT 305 (Calculus IV), or MAT 303 (Calculus IV with Applications), or AMS 361 (Applied Calculus IV: Differential Equations)

Equivalency for MAT courses achieved on the Mathematics Placement Examination is accepted as fulfillment of the corresponding requirements without the necessity of substituting other credits.

### 2.4.1 Upper-division writing requirement

All students majoring in astronomy/planetary sciences must submit two papers (term papers or independent research papers) to the astronomy coordinator for department evaluation by the end of the junior year. If this evaluation is satisfactory, the student will have fulfilled the upper-division writing requirement.

Note that students who are double-majors in Physics and in Astronomy have the option of satisfying *either* major's writing requirement; they do not have to do it twice. The Physics upper-division writing requirement is described in Sec. 2.2.1.

<sup>3</sup><http://www.stonybrook.edu/ugrdbulletin/current/pdfs/astM.pdf>

<sup>4</sup><http://www.astro.sunysb.edu/astro/UGProgram/index.html>

## 2.5 Five year Physics Bachelors and Teaching Masters program

General information on training for, and careers in, the teaching of high school physics is provided in Sec. 4.3. As that section indicates, teacher certification in New York State requires that one earn a Masters Degree within five years of starting their initial teaching job, or that one have the Masters Degree from the outset. To earn a Masters Degree in teaching physics, one must have the course equivalent of a Bachelor of Science degree in Physics from Stony Brook, plus university courses in biology, chemistry and earth sciences, plus education courses from the School for Professional Development<sup>5</sup> and 15 credits of graduate physics. One can instead complete a combined B.S. in Physics and M.A. in Teaching Physics<sup>6</sup> in a total of five years, in preparation for teaching certification in New York State. A student entering the BS/MAT program in the fall of their senior (fourth) year would satisfy all of the requirements for the B.S. in Physics and the MAT separately, with the recognition that some of the B.S. requirements could be satisfied by taking the graduate course which includes the subject matter of the relevant undergraduate course required for the BS:

Graduate course	Undergraduate course
PHY 515	PHY 445
PHY 571	PHY 301
PHY 573	PHY 303
PHY 576	PHY 306
PHY 578	PHY 308

For further information on the five-year BS/MAT program, contact Prof. Robert McCarthy (Robert.McCarthy@stonybrook.edu, office D-104, phone 632-8086).

## 2.6 Minor in Physics

The minor in physics is available for those who want their formal university records to emphasize a significant amount of upper-division work in physics. For the Minor in Physics, the official requirements are listed in the undergraduate bulletin<sup>7</sup>, but we summarize them here for informational purposes. Completion of the minor requires 20 credits. All courses offered for the minor must be passed with a letter grade of C or higher. Requirements for the Minor in Physics for students with majors in the College of Arts and Sciences are:

- PHY 251/252 (Modern Physics plus laboratory) plus, of course, its prerequisites of PHY 125, 126, 127 or PHY 131, 132 or PHY 141, 142
- PHY 300 (Waves and Optics)
- PHY 301 (Electromagnetic Theory I)
- PHY 303 (Mechanics)
- One of the following: PHY 306 (Thermodynamics, Kinetic Theory, and Statistical Mechanics) or CHE 302 (Physical Chemistry II)
- PHY 335 (Electronics and Instrumentation Laboratory)

Requirements for the Minor in Physics for students with majors in the College of Engineering and Applied Sciences are:

- PHY 251 (Modern Physics) plus, of course, its prerequisites of PHY 125, 126, 127 or PHY 131, 132 or PHY 141, 142
- One of the following: PHY 300 (Waves and Optics) or ESE 321 (Electromagnetic Waves and Wireless Communication) or ESG 281 (An Engineering Introduction to the Solid State)

<sup>5</sup><http://www.sunysb.edu/spd/>

<sup>6</sup><http://sbhep1.physics.sunysb.edu/teachers/>

<sup>7</sup><http://www.stonybrook.edu/ugrdbulletin/current/pdfs/phyM.pdf>

- One of the following: PHY 301 (Electromagnetic Theory I) or ESE 319 (Introduction to Electromagnetic Fields and Waves)
- PHY 303 (Mechanics)
- One of the following: PHY 306 (Thermodynamics, Kinetic Theory, and Statistical Mechanics), or ESM 309 (Thermodynamics of Solids), or MEC 398 (Thermodynamics II).
- One of the following: PHY 335 (Electronics and Instrumentation Laboratory) or ESE 314 (Electronics Laboratory B)

## 2.7 Minor in Optics

The minor in optics, which is housed in the Department of Physics and Astronomy, is intended for students outside the physics major who wish to obtain a thorough understanding of the nature of light and its interactions with matter. After learning the basic principles of optics in PHY 300, students may pursue their scientific or professional interests by taking further courses in the Department of Physics and Astronomy or the College of Engineering and Applied Sciences.

The official requirements are listed in the undergraduate bulletin<sup>8</sup>, but we summarize them here for informational purposes. All courses offered for the minor must be passed with a letter grade of C or higher. Completion of the minor requires 21 credits. The required courses are:

- PHY 132 or 142 (Classical Physics II)
- PHY 251/252 (Modern Physics and Laboratory) or ESG 281 (An Engineering Introduction to Solid State)
- PHY 300 (Waves and Optics)
- PHY 301 (Electromagnetic Theory I) or ESE 319 (Introduction to Electromagnetic Fields and Waves)
- At least two of the following:
  - ESE 321 Electromagnetic Waves and Fiber Optics
  - ESE 362 Optoelectronic Devices and Optical Imaging Techniques
  - ESE 441 Engineering Design I\*
  - ESE 499 Research in Electrical Sciences\*
  - ESG 441 Engineering Science Design IV\*
  - ESM 499 Research in Materials Science\*
  - MEC 342 Introduction to Experimental Stress
  - MEC 441 Mechanical Engineering Design II\*
  - MEC 499 Research in Mechanical Engineering\*
  - PHY 302 Electromagnetic Theory II
  - PHY 452 Lasers
  - PHY 487 Research\*

\*These courses may be used if the research project is in optics. Each such course must be taken for three credits and the student must obtain written approval of the Department of Physics and Astronomy for his or her research proposal before starting research.

## 2.8 Example programs of study

We list here several examples of programs of study. For any physics or astronomy major, try to fit in some seminar courses like PHY 104, PHY 200, AST 100, or AST 200!

<sup>8</sup><http://www.stonybrook.edu/ugrdbulletin/current/pdfs/optM.pdf>

## 2.8.1 Physics Major assuming prior credit for MAT 131, 132

An example program of studies for a student starting with previous credit for MAT 131 and 132 is shown below. Courses in **bold** text satisfy requirements.

### Sample Course Sequence for a Physics Major with prior credit for MAT 131 & 132

<b>Freshman</b>	Fall	Credits
First Year Seminar 101		1
WRT 101-A Introductory Writing Workshop		3
<b>PHY 141-E Classical Physics I Honors</b>		4
<b>Physics related elective</b>		3
MAT 111 Introduction to Linear Algebra		3
DEC B Interpreting Texts in Humanities		3
Total		17

<b>Freshman</b>	Spring	Credits
First Year Seminar 102		1
WRT 102-A Intermed Writing Workshop A		3
<b>PHY 142-E Classical Phy II Honors</b>		4
<b>MAT 205 Calculus III</b>		3
<b>Physics related elective</b>		3
DEC D Understanding Fine/Perform Arts		3
Total		17

<b>Sophomore</b>	Fall	Credits
PHY 200 Physics Today		1
<b>PHY 251/252 Modern Physics</b>		4
<b>PHY 277 Computation in Phys &amp; Astro</b>		3
<b>MAT 305 Calculus IV</b>		3
DEC F Social Behavioral Sciences		3
Total		14

<b>Sophomore</b>	Spring	Credits
<b>PHY 300 Waves and Optics</b>		4
<b>PHY 306 Thermo, Kinetic Theory, Stat Mech</b>		3
MAT 342 Applied Complex Analysis		3
DEC F Social Behavioral Sciences		3
DEC G Humanities		3
Total		16

<b>Junior</b>	Fall	Credits
<b>PHY 301 Electromagnetic Theory I</b>		3
<b>PHY 303 Mechanics</b>		3
PHY 311 Connections in Science		1
<b>Physics related elective</b>		3
MAT 341 Applied Real Analysis		3
DEC G Humanities		3
Total		16

<b>Junior</b>	Spring	Credits
PHY 302 Electromagnetic Theory II		3
<b>PHY 308 Quantum Physics</b>		3
<b>PHY 335 Electronics &amp; Instrument Lab</b>		3
<b>Physics related elective</b>		3
DEC H Implications of Science & Tech		3
Total		15

<b>Senior</b>	Fall	Credits
<b>PHY 445 Senior Lab</b>		3
Physics elective		3
DEC I European Traditions		3
DEC J Beyond European Traditions		3
Elective		3
Total		15

<b>Senior</b>	Spring	Credits
PHY 487 Research		3
Physics elective		3
Physics elective		3
DEC K American Pluralism		3
Elective		3
Total		15

Physics electives include PHY 274 (Physical and Mechanical Foundations of Quantum Mechanics), PHY 302 (Electromagnetic Theory II), PHY 310 (Probability and Statistics for Experimental Physics), PHY 403 (Nonlinear Dynamics), PHY 405 (Advanced Quantum Physics), PHY 407 (Physics of Continuous Media), PHY 408 (Relativity), PHY 431 (Nuclear and Particle Physics), PHY 452 (Lasers), and PHY 487 (Research). Not all courses are offered in each semester; for details see Sec. 2.9.1.

Note: PHY 487 (Research) provides exceptionally valuable experience for students preparing for graduate study in physics or a related science. PHY 487 may be repeated under appropriate circumstances (a different research experience) with the permission of the Director of Undergraduate Studies.

## 2.8.2 Physics Major starting with PHY 131 and MAT 131

An example program of studies for a student starting in PHY 131 and assuming no advanced standing in math is shown below. Courses in **bold** text satisfy requirements.

### Sample Course Sequence for a Physics Major starting with PHY 131 & MAT 131

Freshman	Fall	Credits
First Year Seminar 101		1
WRT 101-A Introductory Writing Workshop		3
<b>PHY 131-E Classical Physics I</b>		4
<b>MAT 131-C Calculus I</b>		4
DEC B Interpreting Texts in Humanities		3
Total		15

Freshman	Spring	Credits
First Year Seminar 102		1
WRT 102-A Intermed Writing Workshop A		3
<b>PHY 132-E Classical Phy II</b>		4
<b>MAT 132 Calculus II</b>		4
DEC D Understanding Fine/Perform Arts		3
Total		15

Sophomore	Fall	Credits
<b>PHY 251/252 Modern Physics</b>		4
<b>PHY 277 Computation in Phys &amp; Astro</b>		3
<b>MAT 203 Calculus III w/ Applications</b>		4
DEC F Social Behavioral Sciences		3
Elective		3
Total		17

Sophomore	Spring	Credits
<b>PHY 300 Waves and Optics</b>		4
<b>MAT 303 Calculus IV w/ Applications</b>		4
<b>Physics related elective</b>		3
DEC F Social Behavioral Sciences		3
DEC G Humanities		3
Total		17

Junior	Fall	Credits
PHY 200 Physics Today		1
<b>PHY 301 Electromagnetic Theory I</b>		3
<b>PHY 303 Mechanics</b>		3
<b>Physics related elective</b>		3
MAT 341 Applied Real Analysis (Recommended)		3
DEC G Humanities		3
Total		16

Junior	Spring	Credits
PHY 302 E & M Theory II (Recommended)		3
<b>PHY 306 Thermo, Kinetic Theory, Stat Mech</b>		3
<b>PHY 308 Quantum Physics</b>		3
<b>Physics related elective</b>		3
DEC H Implications of Science & Tech		3
Total		15

Senior	Fall	Credits
PHY 311 Connections in Science		1
<b>PHY 335 Electronics &amp; Instrument Lab</b>		3
<b>Physics related elective</b>		3
DEC I European Traditions		3
DEC J Beyond European Traditions		3
Physics Elective		3
Total		16

Senior	Spring	Credits
PHY 487 Research		3
<b>PHY 445 Senior Lab</b>		3
Physics elective		3
DEC K American Pluralism		3
Elective		3
Total		15

Physics electives include PHY 274 (Physical and Mechanical Foundations of Quantum Mechanics), PHY 302 (Electromagnetic Theory II), PHY 310 (Probability and Statistics for Experimental Physics), PHY 403 (Nonlinear Dynamics), PHY 405 (Advanced Quantum Physics), PHY 407 (Physics of Continuous Media), PHY 408 (Relativity), PHY 431 (Nuclear and Particle Physics), PHY 452 (Lasers), and PHY 487 (Research). Try to get MAT 211 (Introduction to Linear Algebra) in there somewhere too! Not all courses are offered in each semester; for details see Sec. 2.9.1.

Note: PHY 487 (Research) provides exceptionally valuable experience for students preparing for graduate study in physics or a related science. PHY 487 may be repeated under appropriate circumstances (a different research experience) with the permission of the Director of Undergraduate Studies.

### 2.8.3 Physics Major starting with PHY 125

An example program of studies for a student starting in PHY 125 is shown below. Courses in **bold** text are required.

#### Sample Course Sequence for a Physics Major starting with PHY 125 & MAT 125

<b>Freshman</b>	Fall	Credits
	First Year Seminar 101	1
	WRT 101-A Introductory Writing Workshop	3
	<b>MAT 125-C Calculus A</b>	3
	<b>PHY 125-E Classical Physics A</b>	3
	DEC B Interpreting Texts in Humanities	3
	DEC D Understanding Fine/Perform Arts	3
	Total	16

<b>Freshman</b>	Spring	Credits
	First Year Seminar 102	1
	WRT 102-A Intermed Writing Workshop A	3
	<b>MAT 126 Calculus B</b>	3
	<b>PHY 127-E Classical Physics C</b>	3
	DEC F Social Behavioral Sciences	3
	DEC G Humanities	3
	Total	16

<b>Sophomore</b>	Fall	Credits
	PHY 200 Physics Today	1
	<b>MAT 127 Calculus C</b>	3
	<b>PHY 126 Classical Physics B</b>	4
	<b>PHY 277 Computation in Phys &amp; Astro</b>	3
	DEC F Social Behavioral Sciences	3
	Total	14

<b>Sophomore</b>	Spring	Credits
	<b>MAT 203 Calculus III w/ Applications</b>	4
	<b>MAT 303 Calculus IV w/ Applications</b>	4
	<b>PHY 251/252 Modern Physics</b>	4
	DEC G Humanities	3
	Total	15

<b>Junior</b>	Fall	Credits
	<b>PHY 300 Waves and Optics</b>	4
	<b>PHY 301 Electromagnetic Theory I</b>	3
	<b>PHY 303 Mechanics</b>	3
	PHY 311 Connections in Science	1
	<b>Physics related elective</b>	3
	Elective	3
	Total	17

<b>Junior</b>	Spring	Credits
	PHY 302 E & M Theory II (Recommended)	3
	<b>PHY 306 Thermo, Kinetic Theory, Stat Mech</b>	3
	<b>PHY 308 Quantum Physics</b>	3
	<b>Physics related elective</b>	3
	DEC H Implications of Science & Tech	3
	Total	15

<b>Senior</b>	Fall	Credits
	<b>PHY 335 Electronics &amp; Instrument Lab</b>	3
	<b>Physics related elective</b>	3
	DEC I European Traditions	3
	DEC J Beyond European Traditions	3
	Physics Elective	3
	Total	15

<b>Senior</b>	Spring	Credits
	PHY 487 Research	3
	<b>PHY 445 Senior Lab</b>	3
	<b>Physics related elective</b>	3
	DEC K American Pluralism	3
	Elective	3
	Total	15

Physics electives include PHY 274 (Physical and Mechanical Foundations of Quantum Mechanics), PHY 302 (Electromagnetic Theory II), PHY 310 (Probability and Statistics for Experimental Physics), PHY 403 (Nonlinear Dynamics), PHY 405 (Advanced Quantum Physics), PHY 407 (Physics of Continuous Media), PHY 408 (Relativity), PHY 431 (Nuclear and Particle Physics), PHY 452 (Lasers), and PHY 487 (Research). Try to get MAT 211 (Introduction to Linear Algebra) in there somewhere too! Not all courses are offered in each semester; for details see Sec. 2.9.1.

Note: PHY 487 (Research) provides exceptionally valuable experience for students preparing for graduate study in physics or a related science. PHY 487 may be repeated under appropriate circumstances (a different research experience) with the permission of the Director of Undergraduate Studies.

## 2.8.4 Astronomy Major starting with PHY 131

An example program of studies for a student starting in PHY 131 is shown below. Courses in **bold** text satisfy requirements.

### Sample Course Sequence for the Astronomy Major starting with PHY 131

Freshman	Fall	Credits
First Year Seminar 101		1
WRT 101-A Intro Writing Workshop		3
<b>MAT 131-C Calculus I</b>		4
<b>PHY 131-E Classical Physics I</b>		4
DEC B Interpreting Texts in Humanities		3
Total		15

Freshman	Spring	Credits
First Year Seminar 102		1
WRT 102-A Intermed Writing Workshop A		3
<b>MAT 132 Calculus II</b>		4
<b>PHY 132-E Classical Phy II</b>		4
DEC D Understanding Fine/Perform Arts		3
Total		15

Sophomore	Fall	Credits
AST 205 Intro to Planetary Sci or Elective*		3
<b>MAT 203 Calculus III w/ Applications</b>		4
<b>PHY 251/252 Modern Physics</b>		4
<b>PHY 277 Computation for Phys &amp; Astro</b>		3
DEC F Social Behavioral Sciences		3
Total		17

Sophomore	Spring	Credits
AST 200 Astron Research Stony Brook		1
<b>AST 203 Astronomy</b>		4
<b>MAT 303 Calculus IV w/ Applications</b>		4
<b>PHY 300 Waves and Optics</b>		4
DEC G Humanities		3
Total		16

Junior	Fall	Credits
AST 205 Intro to Planetary Sci or Elective*		3
<b>AST 341 Stars and Radiation</b> <sup>†</sup>		3
PHY 301 Electromagnetic Theory I		3
DEC F Social Behavioral Sciences		3
DEC G Humanities		3
Total		15

Junior	Spring	Credits
<b>AST 346 Galaxies</b> <sup>‡</sup>		3
PHY 302 Electromagnetic Theory II		3
<b>PHY 306 Thermo, Kinetic Theory, Stat Mech</b>		3
DEC H Implications of Science & Tech		3
Elective		3
Total		15

Senior	Fall	Credits
<b>AST 443 Obs Tech Optical Astronomy</b> <sup>†</sup>		3
PHY 303 Mechanics		3
DEC I European Traditions		3
DEC J Beyond European Traditions		3
Elective		3
Total		15

Senior	Spring	Credits
<b>AST 347 Cosmology</b> <sup>‡</sup>		3
PHY 308 Quantum Physics		3
PHY 310 Prob & Stat Exp Phys		3
DEC K American Pluralism		3
Elective		3
Total		15

\* AST 205 is taught Fall term of even numbered years.

<sup>†</sup> AST 341 and AST 443 are offered alternate Fall semesters.

<sup>‡</sup> AST 346 and AST 347 are offered alternate Spring semesters.

## 2.8.5 Computer Science Major/Physics Minor

A large number of students graduate with computer science degrees each year in the U.S. Students can distinguish themselves by not only knowing computer science, but also having a significant background in physics since much of computing involves modeling physical phenomena (*e.g.*, weather prediction, finite element analysis, aerodynamic design). While it is the student's responsibility to verify that a program of study will meet current Computer Science degree requirements<sup>9</sup>, as of Fall 2007 an example program that can lead to a Computer Science Major with a Physics Minor is:

<sup>9</sup><http://www.stonybrook.edu/ugrdbulletin/current/pdfs/cseM.pdf>

## Sample Course Sequence for a Computer Science Major/Physics Minor

<b>Freshman</b>	Fall	Credits
First Year Seminar 101		1
D.E.C. A		3
CSE 110 Introduction to CS		3
MAT 131-C Calculus I		4
PHY 131-E Classical Physics I		4
D.E.C.		3
<b>Total</b>		<b>18</b>

<b>Freshman</b>	Spring	Credits
First Year Seminar 102		1
D.E.C. A		3
CSE 114 Computer Sci I		4
MAT 132 Calculus II		4
PHY 132-E Classical Physics II		4
<b>Total</b>		<b>16</b>

<b>Sophomore</b>	Fall	Credits
CSE 214 Computer Science II		3
CSE 215 Foundations of CS		3
AMS 261 Calculus III		4
PHY 300 Waves and Optics		4
D.E.C.		3
<b>Total</b>		<b>17</b>

<b>Sophomore</b>	Spring	Credits
CSE 219 Computer Science III		3
CSE 220 Computer Organization		3
AMS 361 Calculus IV		4
PHY 251/252 Modern Physics		4
D.E.C.		3
<b>Total</b>		<b>17</b>

<b>Junior</b>	Fall	Credits
CSE 300 Technical Writing		1
CSE Software elective		3
CSE 303 Theory of Computation		3
AMS 210 Applied Linear Algebra		3
PHY 303 Classical Mechanics		3
D.E.C.		3
<b>Total</b>		<b>16</b>

<b>Junior</b>	Spring	Credits
CSE 302 Prof Ethics for CS		1
CSE 373 Analysis of Algorithms		3
CSE Software elective		3
AMS 310 Probability & Statistics		3
PHY 306 Thermodynamics		3
D.E.C.		3
<b>Total</b>		<b>16</b>

<b>Senior</b>	Fall	Credits
CSE 308 Software Engineering		3
CSE Hardware Course		3
CSE Elective		3
AMS 301 Finite Math. Structures		3
PHY 301 Electromagnetic Theory I		3
D.E.C.		3
<b>Total</b>		<b>18</b>

<b>Senior</b>	Spring	Credits
CSE Software Elective		3
CSE Elective		3
CSE Elective		3
PHY 335 Junior Laboratory		3
D.E.C.		3
D.E.C.		3
<b>Total</b>		<b>18</b>

Notes:

- Students must get prior approval to substitute upper division Physics courses for the CSE natural sciences requirement.
- CSE Software courses (three required) can include CSE 304; 305; 306 or 307; 328 or 333.
- CSE Hardware courses (one required) can include CSE 310, CSE 320, CSE 346, or ESE 345.
- CSE Electives (three required) can include any upper-division CSE courses excluding CSE 475, 488, 495 and 496.

## 2.9 Courses

A separate web page<sup>10</sup> provides a list of all courses offered in the department, along with links to course descriptions from the undergraduate bulletin, and individual course web pages maintained by course instructors.

### 2.9.1 What courses are offered what semesters?

Our department offers a large variety of courses. The frequency of offering courses is based in part on student demand, on requirements for the major, and on faculty availability. In the lists that follow, 200 and higher courses required for the Physics major are shown in **bold**, and those required for the Astronomy major are shown in *italics*; they are expected to be offered fairly consistently on the schedule shown. Occasionally one or more of the required courses might be offered both semesters. For elective courses, the lists below are just best guesses, not a promise of what will definitely happen.

The following courses are generally offered both semesters:

- AST 101 (Introduction to Astronomy)
- AST 105 (Introduction to the Solar System)
- AST 112 (Astronomy Lab)
- AST 248 (The Search for Life in the Universe)
- PHY 121/123 and 122/124 (Physics for the Life Sciences I/II)
- PHY 125 (Classical Physics A)
- PHY 131/133 and 132/134 (Classical Physics I/II)
- PHY 251/252** (Modern Physics/Lab)
- PHY 277** (Computation for Physics and Astronomy)
- PHY 300** (Waves and Optics)
- PHY 335** (Electronics and Instrumentation Laboratory)
- PHY 445** (Senior Laboratory)

The following courses are generally offered each fall:

- AST 100 (Astronomy Today)
- AST 205 (Introduction to Planetary Sciences—offered in the fall on even-numbered years)
- AST 301 (Collisions in the Solar System) and AST 304 (The Universe) are offered in alternating years. The pattern at present is for AST 301 to be offered in the fall of even-numbered years, and AST 304 to be offered in the fall of odd-numbered years.
- AST 341* (Stars and Radiation) and AST 443 (Observational Techniques in Optical Astronomy) are offered in alternating years. The pattern at present is for AST 341 to be offered in the fall of even-numbered years, and AST 443 to be offered in the fall of odd-numbered years.
- PHY 126 (Classical Physics B)
- PHY 141 (Classical Physics I: Honors)
- PHY 301** (Electromagnetic Theory I)
- PHY 303** (Mechanics)
- PHY 313 (Mystery of Matter)
- PHY 315 (Cosmic Rays: Experimental Research for Non-Physics Majors)
- PHY 405 (Advanced Quantum Physics)
- PHY 472 (Solid-State Physics)

The following courses are generally offered each spring:

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<sup>10</sup>[http://www.astro.sunysb.edu/dugs/ug\\_courses.html](http://www.astro.sunysb.edu/dugs/ug_courses.html)

AST 200 (Astronomical Research at Stony Brook)

AST 203 (Astronomy)

AST 346 (Galaxies) and AST 347 (Cosmology) are offered in alternating years. The pattern at present is for AST 346 to be offered in the spring of odd-numbered years, and AST 347 to be offered in the spring of even-numbered years.

PHY 104 (Opportunities in Physics)

PHY 127 (Classical Physics C)

PHY 142 (Classical Physics II: Honors)

PHY 200 (Physics Today)

PHY 237 (Climate and Atmosphere; crosslisted with ATM 237)

PHY 302 (Electromagnetic Theory II)

**PHY 306** (Thermodynamics, Kinetic Theory, and Statistical Mechanics)

**PHY 308** (Quantum Physics)

PHY 310 (Probability and Statistics for Experimental Physics)

PHY 408 (Relativity)

PHY 431 (Nuclear and Particle Physics)

PHY 452 (Lasers)

The following courses were offered in Summer session I, 2009:

AST 101 (Introduction to Astronomy)

PHY 121 (Physics for the Life Sciences I)

PHY 125 (Classical Physics A)

PHY 126 (Classical Physics B)

The following courses were offered in Summer session II, 2009:

PHY 122 (Physics for the Life Sciences II)

PHY 127 (Classical Physics C)

## 2.10 Physics-related courses approved for the Physics Major

The courses listed below may be used to satisfy the requirement for 12 credits of physics-related courses for the Physics major. The intent is to round out the list of courses required for the major with courses in other quantitative sciences, or upper-division courses that concentrate on the implications of science and technology. These courses are intended to complement a Physics major's education in preparing her/him for successful employment in physics or a related field.

**AMS:** 102, 110, 201, 210, and most 300 level courses (excluding 361).

**AST:** 203, 205, 287, 341, 346, 347, 443, 447, and 487.

**ATM:** 205, 247, 305, 320, 343, 345, 346, 348, 397, 447, 487

**BIO:** 202, 203, 310, 311, and many other 300 level courses.

**BME:** 212, 301, and many other 300 level courses.

**CHE:** 131, 132, 133, 134, 141, 142, 143, 144, 221, 301, 302, and most other 300 level courses

**CSE:** 113, 114, 213, 214, and many other 200 and 300 level courses.

**ECO:** 303, 305, 310, 321, 355, 373

**ESE:** many 200 and 300 level courses.

**ESG:** 281, 302, and many 300 level courses.

**ESM:** 221, and most 300 level courses.

**EST:** 291, 300, 320, 392, 393, 411, 499

**GEO:** 122, 287, and most 300 level courses.

**HBM:** 320, 321

**HIS:** 237, 238, 398

**HON:** 301

**ISE:** 332

**MAR:** most 300 level courses.

**MAT:** 211, and most 300 level courses (excluding MAT 303 and 305).

**MEC:** 290, and most 300 level courses.

**PHI:** 335, 364

**POL:** 411

**PSY:** 355

**SCI:** 410, 420, 447

**SSE:** 350

**WSE:** 187, 242

## **2.11 Advanced physics-related courses approved for the Astronomy Major**

The courses listed below may be used to satisfy the requirement for 8 credits of advanced physics-related courses for the Astronomy major. This list contains the standard courses, but is not exclusive. If another course is of interest and appears to qualify, ask.

**ATM:** 345, 346, 348

**ESE:** 319 (but not together with PHY 301 or PHY 302)

**GEO:** 301

**PHY:** 301, 302, 303, 308, 310, 403, 405, 407, 408, 431, 445

## **2.12 Transfer credits/AP credits**

To apply for transfer credits, please bring the following to the Physics & Astronomy department office:

- Description of your physics course, and any math pre- and/or co-requisites. In most cases you can print this out from a university's web page. *If your course is already listed in Table 2.1, we don't need this information from you.*
- A copy of your transcript.
- A transfer credit form. You can get them from the transfer office on campus, or from the Physics & Astronomy Department office.

Questions about transfer credits should be addressed to Professor Deane Peterson, Physics Building, Room P105, (631) 632-8758.

Biology and biochemistry students should pay particular attention to the math pre-requisites of physics courses at other institutions. Stony Brook's PHY 121/122 sequence has calculus as a pre-requisite, and the biology and biochemistry majors at Stony Brook require a year calculus-based physics including labs to meet the requirements of the major. In comparison, courses such as PHY 53/54 at Suffolk County Community College (which sounds from its course descriptions like it might be similar to Stony Brook's PHY 121/122) which do *not* require calculus as a pre-requisite are *not* regarded as transfer equivalents to Stony Brook's PHY 121/122 (see Table 2.1). To confound the situation, most but not all medical schools will accept physics with algebra; a smaller number require physics with calculus. To summarize:

- If you're planning on being a biochemistry or biology major at Stony Brook, take the PHY 121/122 sequence at Stony Brook or a calculus-prerequisite sequence at another institution (this may put you in with engineers and physics majors at another institution; again, see Table 2.1).
- If you're aiming for medical school and your major at Stony Brook does not require calculus-based physics, you will be OK for many but not all medical schools if you take a pre-med type physics course at another institution. However, physics courses without calculus at other institutions will transfer in as generic DEC E credits at Stony Brook, rather than as PHY 121/122 credits.

Biology and Biochemistry majors are advised to check with their respective undergraduate program offices if they have further questions on physics requirements for their major.

In some cases students will have had courses that are equivalents to the lecture parts of PHY 121/122 but not the labs PHY 123/124, or the lecture parts of PHY 131/132 but not the labs PHY 133/134. In those cases, students can take the courses PHY 191 and 192. Let's say you receive transfer credit for PHY 121 but not the lab PHY 123. You can then sign up for PHY 191, take the labs as if you were registered for PHY 123, and have the PHY 123 lab T.A. report the lab grade to Prof. Peterson<sup>11</sup> for reporting as the grade received in PHY 191.

American students sometimes have the option to take Advanced Placement (AP) physics courses in high school. They then take an exam to demonstrate competency at the end of the semester. Note that foreign students are also able to take these exams to gain college credit based on high school courses in their home country. The Physics & Astronomy department policy on AP credit equivalencies is:

AP Physics exam	Score	Equiv. course	Credits	DEC
B	3, 4 or 5	none	3	E
C: Mechanics	4 or 5	PHY 125	4	E
	3	none	2	none
C: Electrical and Magnetic	4 or 5	PHY 127	4	E
	3	none	2	none

Note that these students must still take the laboratory classes PHY 133 and PHY 134 at Stony Brook (by registering for PHY 191 and PHY 192 as described in the previous paragraph). Further information on the AP exams, exam dates, fees, and so on is available at the College Board web page<sup>12</sup>.

Students who have come to Stony Brook from countries with a British-derived education system will sometimes have taken the Cambridge A-level ("Advanced", not "Advanced Subsidiary") exams<sup>13</sup>. Scores of "A", "B", or "C" on the A-level physics exam are accepted for credit for PHY 131/133, and 132/134 combined.

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<sup>11</sup><mailto:Deane.Peterson@stonybrook.edu>

<sup>12</sup><http://www.collegeboard.com/ap/students/index.html>

<sup>13</sup><http://www.cie.org.uk>

Institution	Algebra-based DEC E credit	PHY 121/122 equiv.			PHY 125/126/127 equiv.			PHY 131/132 equiv.		
		PHY 121+123	PHY 122+124	PHY 125	PHY 126	PHY 127	PHY 131+133	PHY 132+134		
Adirondack CC (SUNY)	PHY 111 & PHY 112			EGR 105	EGR 106	EGR 204				
Ajou University, Korea							Physics I+lab	Physics II+lab		
Baruch College (CUNY)	PHY 2003 & PHY 3001						PHY 3010	PHY 3020		
Borough of Manhattan CC (CUNY)	PHY 210 & PHY 220						PHY 215	PHY 225		
Bronx CC (CUNY)	PHY 11 & PHY 12			PHY 31	PHY 32	PHY 33				
Broome CC (SUNY)							PHY 181	PHY 182		
City College (CUNY)	PHY 20300 & PHY 20400						PHY 20700	PHY 20800		
College of Staten Island (CUNY)	PHY 110+111 & PHY 150+151, PHY 116 & PHY 156						PHY 120+121	PHY 160+161		
Hudson Valley CC (SUNY)	PHYS 140 & PHY 141			PHY 150	PHY 250	PHY 151				
Hunter College (CUNY)	PHYS 110 & PHY 120						PHYS 111	PHYS 121		
Kingsborough CC (CUNY)	PHY 11 & PHY 12						PHY 13	PHY 14		
Laguardia CC (CUNY)	SCP 201 & SCP 202						SCP 231	SCP 232		
Nassau County CC (SUNY)	PHY 101 & PHY 102			PHY 122	PHY 123	PHY 222	PHY 151	PHY 152		
New Paltz (SUNY)							PHY 201+211	PHY 202+212		
NYC Technical College (CUNY)	SC 433 & SC 434						SC 441	SC 442		
NY Inst. of Tech, Westbury				PHYS 175	PHYS 185	PHYS 180				
Orange County CC (SUNY)	PHY 101 & PHY 102			PHY 103	PHY 104	PHY 203	PHY 105	PHY 106		
Polytechnic University, Brooklyn							PH 1004	PH 2004		
CW Post College (L. I. University)	PHY 11, PHY 12						PHY 3	PHY 4		
Queen's College (CUNY)	PHYS 121 & PHYS 122						PHYS 145	PHYS 146		
Queensborough CC (CUNY)	PH 201 & PH 202, PH 301 & PH 302									
Queensborough CC (CUNY)	PHY 101 & PHY 102			PH 411	PH 412	PH 413				
Rockland CC (SUNY)							PHY 101H	PHY 102H		
St. John's University	PHY 1610 & PHY 1620						PHY 105	PHY 106		
Suffolk County CC (SUNY)	PHY 53/101 & PHY 54/102			PHY 71+72, PHY 130+132	PHY 75+76, PHY 245+246	PHY 73+74, PHY 230+232	PHY 1930	PHY 1940		
SUNY Albany	PHY 105+106 & PHY 108+109						PHY 140+145	PHY 150+155		
SUNY Binghamton	PHY 121 & PHY 122						PHY 131	PHY 132		
SUNY Cobleskill	PHYS 111+X & PHYS 112+X			PHYS 211+X	PHYS 212+X					
SUNY Farmingdale	PHYS 135 & PHYS 136			PHY 151+161	PHY 253+262	PHY 152	PHY 143	PHY 144		
Westchester CC (SUNY)	PHYS 123+124 & PHYS 125+126						PHYS 101+2	PHYS 103+4		
York College (CUNY)				PHYS 101	PHYS 102		PHYS 151	PHYS 152		

Table 2.1: Transfer course equivalencies from a variety of regional institutions as of July 2009 (subject to change). Students who are biology or biochemistry majors should take a course that transfers as an equivalent of PHY 121/122 or PHY 131/132. That is, if they wish to take physics at another institution and that institution does not offer a calculus-based equivalent to PHY 121/122, they should take a PHY 131/132 equivalent instead. (Note: &'s indicate courses in a sequence, + 's indicate a lecture/lab pair numbered separately).

## 2.13 Student ethics and academic honesty

As a student in physics, you are not only learning about the subject material of one of the sciences but entering the culture and ethical framework of scientists. We strive to teach you this ethos as it applies to our classes; you should also read the report **On Being a Scientist: Responsible Conduct in Research** which is available from the National Academies of Sciences web site<sup>14</sup>.

Science is built on the presumption that you can build upon the knowledge of others to further understand how nature works; fraud, dishonesty, or even sloppiness can all violate that foundational principle. Science is also built upon the idea that results should be reproducible by anyone with the right equipment and materials. Many cases of fraud have been discovered when researcher A tries to extend the ideas of researcher B but without success; researcher A may then try to reproduce the results of researcher B to make sure they've got the basic technique down, and if *that* doesn't work then further questions begin to be raised until the fraud is uncovered. . .

In exams, students are generally allowed to bring pocket calculators unless specifically prohibited by the professor. The use of devices such as Palm or PocketPC based personal digital assistants, or laptop computers, during exams is prohibited. Cell phones, pagers, and related devices must be turned off and put out of sight during the exam, as described on the Academic Judiciary web pages<sup>15</sup>.

In most cases we encourage students to work together in their struggles with homework. However, in the end you should write out your own solution in your own words. Remember that when the exam comes, you'll have to solve the problems on your own so you are only hurting your own preparedness for exams if you simply copy down homework answers from others. Written reports should also be in your own words; reports with passages taken from web sites or other published work without citation constitute plagiarism. Further guidelines on academic honesty, including specific discussions of what does and does not constitute plagiarism, are listed on the Academic Judiciary web pages<sup>16</sup>.

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<sup>14</sup><http://stills.nap.edu/html/obas/>

<sup>15</sup><http://naples.cc.stonybrook.edu/CAS/ajc.nsf/pages/info>

<sup>16</sup><http://naples.cc.stonybrook.edu/CAS/ajc.nsf/pages/info>

## Chapter 3

# Undergraduate research

Undergraduate research is a priority for Stony Brook University, and there is a separate office for Undergraduate Research and Creative Activities (URECA)<sup>1</sup>. Photos from the 2002 Celebration of Undergraduate Achievements are shown here<sup>2</sup>

Sam Roberts (then president of the Stony Brook Chapter of the Society of Physics Students (see Sec. 4.4) commented in May 2002 regarding our department: “The research opportunities here are SOooo plentiful. . . If anyone has any complaints about that, they are simply not looking hard enough!!” Of course, for an undergraduate who hasn’t done it yet, it is not at all obvious how one should “look.” The short answer is, connect with a researcher and do it! Here are some ways to get started:

1. See the web page<sup>3</sup> on undergraduate research in the department, including a list of project ideas, past projects, and so on.
2. Visit the Laser Teaching Center<sup>4</sup> and speak with the director, Dr. John Noé<sup>5</sup>.
3. Talk with a professor you know from a class. Ask for advice about doing research.
4. Talk with the undergraduate program director, Prof. Deane Peterson, in room P-105.
5. Ask other students. Especially ask graduate students, such as your lab TA. Lab TA’s are usually not yet doing their thesis research, but they should be able to introduce you to older students and suggest areas of research and professors. Ask Elaine and the other secretaries in the department office!
6. Look in Sec. 4.7 for more information on fellowships, internships, and so on.

### 3.1 What is meant by research?

There are two principal styles of research for undergraduates: *self-directed*, and *guided*. *Self-directed* means you formulate your own problem, and get guidance about where to borrow the equipment, how to fix it, how to calibrate it, *etc.* *Guided* means that a scientist suggests the problem to you and gives you access to the resources. Both styles are valuable. Self-directed research is what mature research scientists generally want to do. It can be done by an individual or a group which directs itself by internal discussion. Undergraduates who have the chance to do this are learning the most valuable skill of all: how to formulate questions about nature in such a way that they have a chance of being answered by a measurement. Guided research is what most graduate students are doing, and undergraduates can do it too. They are learning the details of a specialized area of research by doing it. Since they are not experts at the beginning, they need guidance from their professor about what questions sit at the frontier and are susceptible to attack at a given moment with available equipment or expertise. At the same time, the professor is not acting out of purely generous motives. The professor has a research agenda and the student is a necessary partner to advance the agenda. The graduate student typically spends at least two and a half years at this before writing a thesis and graduating with a PhD. While the research is progressing, usually there are interesting results which get published, most

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<sup>1</sup><http://www.sunysb.edu/ureca/>

<sup>2</sup><http://resonator.physics.sunysb.edu/laser/news/cua2002/>

<sup>3</sup><http://undergrad.physics.sunysb.edu/research/>

<sup>4</sup><http://resonator.physics.sunysb.edu/laser/>

<sup>5</sup><http://nuclear.physics.sunysb.edu/~noe/>

often as joint papers between the student and the other members of the research group who are helping on the project. The undergraduate does not have 2.5 years to spend in the lab. Sometimes a scientist can give to an undergraduate projects which yield very interesting results on a much shorter time scale. Sometimes publishable research papers result. **For Stony Brook faculty, it is safe to say that nothing gives them more pleasure than to mentor a student (undergraduate or graduate) who makes real progress on a project.** Most professors will suggest guided rather than self-directed research. A great place to do self-directed research is the Laser Teaching Center.

### 3.2 Who can guide research? Should you get academic credit?

You may want first to try a research program for a semester without academic credit, or for a small number of credits. You may want to do it over the summer for no credit so that you are not paying tuition (in which case you should register for the zero-credit course PHY/AST 287 or 487) to make sure that you are covered by university insurance policies). There are courses PHY/AST 287.xx and PHY/AST 487.xx, where the section, xx, refers to a particular professor. You have to ask the professor whether it is possible to do such a course, and negotiate how many credits should be assigned. The professor then has to decide what to do. Some factors which guide this decision are (a) whether the professor has time (there may be too many students in the group already) (b) whether an appropriate project can be found (second year undergraduates are not likely to succeed in projects requiring advanced physics and math, for example), and (c) whether the professor has the feeling that you are someone who will be fun to work with. It is often kosher to arrange to have your research directed by someone outside the physics department. Perhaps 15% of students are doing this at any time. If you want to get credit for 287 or 487 for work being done with a professor of Engineering (for example) or medicine or chemistry, it can be done in the following way. First, the project should be “physics-related.” Ask your research mentor to choose as a contact person, a Physics and Astronomy professor (for example, the undergraduate program director). The contact person can then act as “official” sponsor of the research, with the real research mentor assigning the grade under the signature of the contact person.

### 3.3 Why join a research Group?

1. You may get some desk space. You are certainly entitled to ask for space if you spend 5 or 10 hours a week hanging out with a research group. If the professor doesn't know of any available space, he can ask the department to help.
2. You will interact with people sharing some common concerns. Probably you will interact with fellow undergraduates, graduate students, post-docs, staff, and faculty, much more than would happen if you had no research group affiliation.
3. You will have a better connection which helps when it is time to ask a faculty member for recommendation letters.
4. You should have fun (well, OK, maybe not all the time, but at least some of the time!).
5. You will learn things which give some perspective on the course work. You will not be shocked when you get to senior lab and discover that the apparatus is not going to work until you massage it correctly. You will have a chance to find out which kinds of physics appeal to you, what physicists are like, what their normal activities are.
6. If you are lucky, you will participate in, or even lead, the discovery of new knowledge.
7. You may get academic credit, and you may get some stipend (for example you can always ask for a paid summer job.)

### 3.4 When is the right time to join a research group?

As soon as possible is the best answer. The laser teaching center, and many of the experimental groups, offer opportunities for beginning students. If your ambition is to do string theory, you should start in an experimental lab where you can observe and learn about quantum or wave effects in real experimental situations. You can go to professors doing theoretical research to ask for research projects, but not all of them will be able to offer accessible projects, and it is certainly best to get some 300-level courses under your belt first, and some research experience in experimental groups.

### **3.5 What are example research project possibilities?**

Descriptions of example research projects, presentations from the 2001 undergraduate research symposium, and so on are located at

<http://undergrad.physics.sunysb.edu/research/>

This list is not exhaustive; there are several professors who have often had undergraduate student research programs going but who are not listed there. Ask around!

### **3.6 Undergraduate research gatherings**

Information on undergraduate research gatherings (symposia and conferences) is available at

<http://undergrad.physics.sunysb.edu/research/>

# Chapter 4

## Resources

### 4.1 Department staff

The mailing address for the Undergraduate Program office is

Undergraduate Program Office  
Department of Physics & Astronomy  
Stony Brook University  
Stony Brook, NY 11794-3800

Specific people to contact are:

- Undergraduate Program Coordinator: Elaine Larsen (Elaine.Larsen@stonybrook.edu, 631-632-8036)
- Undergraduate Program Director: Prof. Deane Peterson (Deane.Peterson@stonybrook.edu, 631-632-8758)
- Astronomy Undergraduate Coordinator: Prof. James Lattimer (James.Lattimer@stonybrook.edu, 631-632-8227, Earth & Space Sciences building room 455)

### 4.2 Advice for undergraduates

Here are paths to enlightenment while you're pursuing your undergraduate degree:

- If possible, choose one of the science oriented First Year Seminars (XXX102) offered spring semester of your Freshman year (1 credit hour).
- Take PHY 200 (Physics Today) or AST 200 (Current Astronomical Research at Stony Brook) or in your Sophomore year (1 credit hour).
- Take PHY 311 (Connections in Science) in the fall of your Junior year (1 credit hour).
- You should find make sure that you are on track in the major requirements for your degree. It is worth checking this at least once a year, and twice as a senior, with the undergraduate program people (see Sec. 4.1): Prof. Deane Peterson (Physics), Prof. James Lattimer (Astronomy), and, of course, Elaine Larsen who can always help out.
- You should make sure that you are on track with the college requirements (CAS, or College of Arts and Sciences, for most Physics and Astronomy majors). In the Academic Advising<sup>1</sup> area, Rosemary Scilipoti is the adviser with a special mandate for Physics and Astronomy, and is very helpful. The other advisers are equally knowledgeable about DEC and other requirements, but have less knowledge of the Physics and Astronomy programs.
- A summer internship can be a great thing; you can put your developing physics skills to use, and/or learn more about what it's like to work in a real research lab. Look in Sec. 4.7 for more information on fellowships, internships, and so on.

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<sup>1</sup><http://www.stonybrook.edu/aadvising/index.shtml>

- It is very desirable to have a professor who knows you well, probably because of a research project that you did under the professor's supervision. This professor can give you an added perspective on the ways of the physics & astronomy world.
- The Society of Physics Students (see Sec. 4.4) in room P-121 offers free tutoring, and fosters a sense of community amongst undergraduate Physics majors.
- You should be aware that Prof. Peter Kahn has a nice web page<sup>2</sup> with a math mini-review and a collection of math and physics problems for practice.
- Note that Prof. Michael Gurvitch (Michael.Gurvitch@stonybrook.edu, D-137, 632-8099) is the senior adviser and provides special guidance to students considering their options as they complete their bachelors degree; a useful source is the previous advisor's website:<sup>3</sup>.
- Learn about what physicists and astronomers do for a living! (Lots of things!) Information on career opportunities, and local and national resources for seeking employment with a physics background, is contained in Sec. 4.9.

### 4.3 Training and Careers in Physics Teaching

Now is a good time to consider a career teaching high school physics. The situation is favorable with lots of students in the schools, and an aging group of secondary school teachers soon to retire. Teachers know that their work makes an important contribution to society. Pay is decent, job security is excellent, and summers are long!

Only about 1/3 of high school physics teachers have a degree in physics or physics education. Graduates with a bachelors degree in physics, and a masters degree in education are in especially high demand. In 1997, the *national* median starting salary for high school physics teachers was \$25K, while the median for "experienced" teachers was \$42K. However, salaries in New York State and in particular on Long Island are considerably higher. Prof. Clifford Swartz reports that a sampling of members of the Long Island Physics Teachers Association indicates that the typical salary after ten years of employment is about \$70K (and that was in 2003!).

There are two rather similar paths to becoming a physics teacher:

1. In one path, you should seek a B.S. in Physics, with a Science Education minor. By majoring in Physics, you will have great competence as a physics teacher and be in high demand when it is time to look for a job. The Science Education minor requires an additional 30 credits, 12 of which can be counted as courses related to the physics major (which are required for the Physics major anyway!).
2. In another path, you should seek a B.S. in Physics, and stay on for an additional year to obtain a Masters in Teaching Physics from the School for Professional Development<sup>4</sup>. In this path, you start your teaching career with a Masters Degree already in your pocket, which you would otherwise have to complete within six years of starting a teaching job. Further details on this five-year BS/MAT program are given in Sec. 2.5.

Additional resources regarding the teaching of physics include:

- You should certainly talk to Prof. Robert McCarthy (Robert.McCarthy@stonybrook.edu, office D-104, phone 632-8086), who coordinates our teacher training programs.
- Visit the Long Island Group Advancing Science Education (LIGASE)<sup>5</sup> offices in 094 Life Sciences. The Director of the program is Prof. R. David Bynam. Inquiries should be sent to (Judith.Nimmo@stonybrook.edu, phone 632-9750).
- In order to see what an active physics teacher does, you might like to check out the web page<sup>6</sup> of Ed Pascuzzi, a physics teacher at Glen Cove High School. Ed did his BS in physics at Stony Brook in 1988.

<sup>2</sup><http://www.mathlab.sunysb.edu/~pkahn/>

<sup>3</sup>[http://sbhep1.physics.sunysb.edu/~rijssenbeek/PHY\\_junior\\_senior\\_Advising.html](http://sbhep1.physics.sunysb.edu/~rijssenbeek/PHY_junior_senior_Advising.html)

<sup>4</sup><http://www.sunysb.edu/spd/>

<sup>5</sup><http://www.stonybrook.edu/ligase/index.shtml>

<sup>6</sup><http://www.thephysicsguy.com>

- The American Institute of Physics has a great web page<sup>7</sup> on physics teaching. Note in particular a report<sup>8</sup> that describes trends in education, and demographics and salary information for science teachers.
- The American Association of Physics Teachers<sup>9</sup> is another great resource.
- The Southern Teachers Agency<sup>10</sup> has listings for Physics teachers at several private/independent schools in the Southeast. These schools are often willing to consider candidates who have a bachelor's degree in Physics (or at least 24 hours in Physics) and a cumulative GPA of at least a 3.0. Candidates need not have teacher certification, and formal teaching experience is not required. For more information, contact their director, R. Carey Goodman, at 434-295-9122 or teachers@southernteachers.com. This agency is a third-party recruiter, its services are paid for by the schools it recruits for, and teacher candidates have no financial obligations to the agency.

**Important note:** The Department of Physics & Astronomy at Stony Brook University does not endorse this or any other placement service; we simply provide this information for the consideration of our students.

## 4.4 Society of Physics Students

As a physics major (astronomy majors are welcome too) you may sometimes find yourself alone struggling with a problem or baffled by the overwhelming choices available at Stony Brook. It is then a comfort to know that you are not alone. The Stony Brook chapter of the Society of Physics Students<sup>11</sup>) is available to help you. SPS is a place where students come to relax, study, socialize, and exchange information. There are often upperclassman there who have “been through it” and can offer valuable advice. With an office located in Room P-121 of the physics building, three couches, a refrigerator, a microwave, and a computer terminal, SPS is a commuter's dream. The office also provides a quiet refuge from the dorms where serious work can be done. In addition to these advantages, SPS organizes tours and trips as well as talks and presentations. In all, SPS presents itself as a great asset to the physics major, bridging the gaps between you, other students, the faculty, and the course material.

## 4.5 Resources for Women and Minorities

The present-day Physics & Astronomy community has not had the same makeup as the nation as a whole, but this is changing. (It is curious to note that France has a relatively large number of women physicists, perhaps due in part to the legacy of Marie Curie who received Nobel Prizes in 1903 and 1911). There are a number of great resources for women and minorities in Physics & Astronomy:

- Project WISE<sup>12</sup> serves Women in Science and Engineering by offering scholarships, seminar courses, mentoring, and special advising. They are located in room P-120 in the Physics building.
- The American Physical Society has special resources for women in Physics on their Committee on Status of Women in Physics web page<sup>13</sup>.
- The American Institute of Physics has considerable statistical data on women and minorities in physics<sup>14</sup>.
- The National Society of Black Physicists<sup>15</sup> and the National Society of Hispanic Physicists<sup>16</sup> provide resources for their respective communities.

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<sup>7</sup><http://www.aip.org/statistics/trends/hstrends.htm>

<sup>8</sup><http://www.aip.org/statistics/trends/reports/hsreport.pdf>

<sup>9</sup><http://www.aapt.org>

<sup>10</sup><http://www.southernteachers.com>

<sup>11</sup><http://felix.physics.sunysb.edu/SPS/>

<sup>12</sup><http://www.wise.sunysb.edu>

<sup>13</sup><http://www.aps.org/educ/cswp/index.html>

<sup>14</sup><http://www.aip.org/statistics/trends/wmtrends.htm>

<sup>15</sup><http://www.nsbp.org>

<sup>16</sup><http://utopia.utb.edu/nshp/>

- The National Science Foundation had a Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology<sup>17</sup> with a July 2000 brochure and report entitled *Land of Plenty: Diversity as America's Competitive Edge in Science, Engineering, and Technology*.

## 4.6 Scholarships

These are some of the scholarships that could be valuable to Physics and Astronomy majors:

- The American Physical Society sponsors a Minority Scholarship<sup>18</sup> for undergraduate majoring in physics. The deadline is always the first Friday in February, open to freshmen and sophomores.
- For US citizens only, the David L. Boren Undergraduate Scholarships<sup>19</sup> offer an opportunity for study abroad in regions critical to U.S. national interest. The application deadline is February 12 in 2008.
- Stony Brook maintains an extensive list of scholarships available, funded both nationally and locally, at web page about scholarships<sup>20</sup>
- The Latin American & Caribbean Studies Center<sup>21</sup> offers an academic achievement award (a \$1000 scholarship) for latino/latina students at Stony Brook.

Please also look at Sec. 4.7 on Fellowships!

## 4.7 Fellowships and research jobs for undergraduates

Here is a list of *some* of the many opportunities out there for fellowships, internships, and research jobs for undergraduates (the SPS office maintains files and a bulletin board that should be consulted as well):

- Many students find summer research positions based on their undergraduate research (see Chapter 3) in our department. The campus Undergraduate REsearch and Creative Activities (URECA) website has a list of on-campus research opportunities<sup>22</sup>.
- Other options include the Research Experience for Undergraduates<sup>23</sup> program of the National Science Foundation. We are allowed to accept only a very few of our own students into the Stony Brook REU<sup>24</sup> program, but there are a number of other REU sites nationwide.
- One can also apply for Science Undergraduate Laboratory Internships (SULI)<sup>25</sup> at the Department of Energy national laboratories. There are additional opportunities<sup>26</sup> at Brookhaven National Laboratory, including Battelle Summer Research Fellowships<sup>27</sup>.
- The Stony Brook Mineral Physics Institute<sup>28</sup> also has summer research opportunities.
- The National Institute of Standards and Technology has a summer undergraduate research fellowship<sup>29</sup> program.
- The scientific research society Sigma Xi offers undergraduate research grants-in-aid<sup>30</sup>

<sup>17</sup><http://www.nsf.gov/od/cawmset/>

<sup>18</sup><http://www.aps.org/programs/minorities/honors/scholarship/index.cfm>

<sup>19</sup><http://www.iie.org/nsep/undergraduate/default.htm>

<sup>20</sup><http://www.stonybrook.edu/scholarships/index.shtml>

<sup>21</sup><http://www.stonybrook.edu/lacc>

<sup>22</sup>[http://www.sunysb.edu/ureca/on\\_campus\\_opps.htm](http://www.sunysb.edu/ureca/on_campus_opps.htm)

<sup>23</sup><http://www.nsf.gov/home/crssprgm/reu/start.htm>

<sup>24</sup><http://www.sunysb.edu/ureca/physicsreu.htm>

<sup>25</sup><http://www.scied.science.doe.gov/scied/erulf/about.html>

<sup>26</sup><http://www.bnl.gov/scied/k12students/university/undergrad/4year/index.html>

<sup>27</sup><http://www.sunysb.edu/ureca/battelle.htm>

<sup>28</sup><http://www.mpi.stonybrook.edu/SummerScholars/>

<sup>29</sup><http://www.surf.nist.gov/surf2.htm>

<sup>30</sup><http://www.sigmaxi.org/programs/giar/index.shtml>

- The Bulletin of the Atomic Scientists<sup>31</sup> is a magazine started by physicists in the aftermath of the Manhattan Project. The foundation associated with the magazine offers the Leonard M. Rieser Fellowship<sup>32</sup> to undergraduate students to explore the connections between science, global security, and public policy.
- Further lists of lists are provided by Sonoma State University<sup>33</sup>, Carleton College<sup>34</sup>.

Please also look at Sec. 4.6 which discusses scholarships!

### 4.7.1 Internships

*This section has been adapted from material provided by the Career Office on campus.*

Internships with either an off-campus employer or a Stony Brook department have become extremely important for undergraduates seeking a competitive advantage for employment and graduate school admission. This is particularly important for students seeking to employment as a B.S. or B.A. recipient in physics.

To seek an internship, you might start by consulting a state-by-state list maintained by the American Institute of Physics of companies that have hired recipients of Bachelors degrees in Physics<sup>35</sup>.

You can gain academic credit for internship experiences. This is described on p. 99 of the Undergraduate Bulletin but the Career Center has composed the checklist below to help you when advising a potential intern.

#### Before the Internship starts

- Review the internship description and discuss credit value of experience with the student. General guidelines: 3 credit internship=12 hours per week. (spending more than 12 hours *does not* automatically increase the credit worthiness of the experience. Also, all experiences called internships are not appropriate for academic credit. The faculty sponsor makes the decision on appropriateness of receiving academic credit.
- Obtain a clear understanding of what is expected at the end of the semester. University guidelines for an internship require a term report and reflection journal.
- Enroll in PHY 488 or AST 488 for internship credit. You can also do internships in other departments, or enroll in EXT 488 if the internship is credit-worthy but not matched to a particular department.
- Set a time for regular meetings throughout the semester. You should have at least four meetings with your faculty adviser for a three credit internship.
- Submit your Internship Agreement form to the Career Center no later than two days before the end of add/drop period.

#### Mid-term

Continue communication with your interns. Career Center staff sends out evaluations to interns and off-campus internship sponsors to assess experiences. The Career Center will only call you if there is a negative evaluation.

#### End of Term

Faculty sponsors are responsible for entering grades (S or U) for interns enrolled in departmental 488 courses. By the end of the term, your faculty sponsor should have at least three pieces of information about your internship: a journal, term report or summary, and a final evaluation from your off-campus supervisor. The Career Center distributes and collects final evaluations from off-campus supervisors. The Career Center submits grades (S or U) for students in EXT 488 after conferring with faculty sponsors.

Whether you do an internship or not, you should register with the Career Center for access to internship listings and other career education information.

<sup>31</sup><http://www.thebulletin.org>

<sup>32</sup><http://www.thebulletin.org/programs/rieser-fellowship.html>

<sup>33</sup><http://www.phys-astro.sonoma.edu/advisor/SummerScienceAvailNow.html>

<sup>34</sup>[http://apps.carleton.edu/curricular/physics/for\\_students/index.html](http://apps.carleton.edu/curricular/physics/for_students/index.html)

<sup>35</sup><http://www.aip.org/statistics/trends/states/state.htm>

## 4.8 Graduate study in Physics

As a Bachelor of Physics and/or Astronomy, you will have a strong background of the main themes of the discipline. About one third of the recipients of bachelors degrees in physics go on to seek graduate degrees to obtain deeper training and to carry out original research in a sub-field of physics. If you are curious about graduate school opportunities, contact Prof. Peterson and Prof. Michael Gurvitch (Michael.Gurvitch@stonybrook.edu, D-137, 632-8049) who is the senior adviser and who provides special guidance to students considering their options as they complete their bachelors degree.

### 4.8.1 PhD programs

For those students emerging from a B.S. program with student loan commitments weighing on their minds, it is important to note that most students in Ph.D. programs receive a teaching or research assistant stipend and a tuition waiver. You won't get rich during your graduate studies, but you are able to live modestly without needing to seek additional financial aid (and you can often defer payment of any student loans you might have from your undergraduate years until you have completed your graduate degree program).

Note that most Ph.D. programs require you to gain some teaching experience (*e.g.*, as a laboratory teaching assistant) as part of obtaining the degree. Doing this during your first year of graduate school is often a good idea; you then take one fewer course, and you spend some of your time interacting with undergraduates and doing something socially useful.

Having said that, it can also be a very nice thing to seek your own fellowship, especially if you want to spend a year abroad before coming back to the US for the rest of your graduate study. One program of this type is the Fulbright program<sup>36</sup> jointly administered by the US Department of State<sup>37</sup>, the J. William Fulbright Foreign Scholarship Board<sup>38</sup>, and the Institute of International Education<sup>39</sup>. Stony Brook students thinking of applying should contact Elizabeth Barnum (Elizabeth.Barnum@stonybrook.edu, phone 632-4685) in the Graduate School<sup>40</sup> at Stony Brook. Deadline for applications for academic year 2003-2004 is September 30, 2002. Another option is provided by the National Science Foundation, which has a graduate fellowship program<sup>41</sup> with an application deadline of November 7, 2002. Both of these programs require that you be a U.S. citizen at the time of your application.

How to pick a graduate school? The American Institute of Physics provides a great starting point at the web site [www.gradschoolshopper.com](http://www.gradschoolshopper.com). There are of course various external rankings<sup>42</sup> of Physics and Astronomy PhD programs out there. Based on rankings provided by the National Research Council, the web site [www.phds.org](http://www.phds.org) has a program by which you can enter your priorities and retrieve a list of the top 50 or so schools ranked according to your priorities and their database. This can be very useful, but don't take the ranking too seriously. Consult professors here about their views on the rankings. For example, our own department got poorly treated. Apparently someone sent data for the physics department with the Yang Institute for Theoretical Physics (YITP) excluded, and based on these data Stony Brook ranks somewhere close to 20, while if YITP data had been included properly, the rank would have been close to 10.

The shortage of qualified applicants has recently been felt in Europe as well as in the US. Therefore, now is a better time than ever before to consider graduate study abroad, if your tastes run in this direction. For example, a good program has recently been announced in Stuttgart, called the International Max Planck Research School for Advanced Materials<sup>43</sup>. You can find a good supply of courses in English, and learn (or even fail to learn) German at your own pace.

### 4.8.2 Masters degree programs

The PhD is a goal for many but does not always make sense. It typically takes 5-6 years to obtain a PhD after receiving the bachelors degree (the normal range is between 3.5 and 8 years). The first year is often quite demanding as you prepare for comprehensive exams and take core courses, uncertain of whether the goal is attainable. Once you get past this, you go about finding the right subfield, project, and thesis adviser. It can be a great experience, but there are no guarantees, and there have been times (in particular in the early 1990s) when the PhD hasn't always led to a satisfying career or employment in science.

<sup>36</sup><http://www.iie.org/Template.cfm?Section=Education&Template=/Activity/ActivityDisplay.cfm&activityid=54>

<sup>37</sup><http://www.state.gov>

<sup>38</sup><http://www.iie.org/Template.cfm?Template=/programs/fulbright/fulboard.htm>

<sup>39</sup><http://www.iie.org>

<sup>40</sup><http://www.grad.sunysb.edu/>

<sup>41</sup><http://www.ehr.nsf.gov/dge/programs/grf/>

<sup>42</sup><http://insti.physics.sunysb.edu/physics/rankings.htm>

<sup>43</sup><http://www.imprs-am.mpg.de/>

For certain people and certain purposes, the PhD is the only way to go. For the rest, there are other options. A bachelor's degree in physics is a good entry to the job market, and a masters degree can be even better.

Starting close to home, Stony Brook offers a Master of Science in Instrumentation<sup>44</sup> degree (the MSI). It is a small program for those students who enjoy experimental physics, have developed laboratory skills, desire to be involved in research in almost any area of science, and want an advanced degree but do not wish to pursue a Ph.D.

Farther afield, Chalmers University in Gothenburg, Sweden is an excellent technical university which has just opened a broad masters program<sup>45</sup> with instruction in English. Physics-related topics include Advanced Materials, Applied Environmental Measurement Techniques, and Nanoscale Physics and Engineering.

### 4.8.3 The Graduate Record Exam (GREs)

Most graduate schools require that their applicants take the GRE or Graduate Record Exam, administered by the Educational Testing Service<sup>46</sup>. Oftentimes one is asked to take both the general exam, and also the Physics subject test. The general exam is given year-round at GRE test centers, while the paper exam, and more importantly the physics subject test exam, has specific test dates and registration deadlines as listed on the GRE test date web site<sup>47</sup>. The (early) November test is best timed for September admissions, but the (early) December test works pretty well too (grades are mailed around mid January). The registration deadline for the exams is usually more than a month earlier!

Prof. Michael Rijssenbeek, a former junior/senior adviser, has a nice web page<sup>48</sup> which has some helpful links concerning the GRE exams which you should consult. Several other colleges also have helpful information on taking the GRE in physics. Here are a few:

- Oberlin<sup>49</sup>
- Vassar<sup>50</sup>
- Worcester Polytechnic Institute<sup>51</sup>

## 4.9 Employment for Physicists and Astronomers

Who Are Hiring Physics or Astronomy Bachelors? Well, lots of people. One must first understand that bachelors degree recipients in Physics & Astronomy are a select crowd: in the year 2000, the number of bachelors degree recipients in physics was about 3,900; in astronomy, about 160; and in engineering, about 60,000. What do members of this crowd do? Well, many choose the rewarding path of teaching physics (see Sec. 4.3). Many others go to industry, or to national laboratories. Because Physics & Astronomy majors are a select crowd, one does not hear as much anecdotal evidence of job recruitment of physicists as one does, say, of engineers. However, that does not mean that a typical company is ignorant of the virtues of hiring Physics & Astronomy bachelors! People with a Physics or Astronomy degree have a reputation for having exceptional analytical skills, and for being especially used to trying to frame solutions to complicated problems. This skill can be applied not just to physics but to other fields, as noted below.

Finally, about a third of those receiving bachelors degrees in Physics & Astronomy go on to graduate school, leading to further career opportunities. This is described further in Sec. 4.8.

Resources available to better understand bachelors degree employment options include:

- The Stony Brook University Career Center<sup>52</sup> is a great place to visit starting early in your student career. When you visit, you can sign up for MonsterTrak and be informed of on-campus recruiting events from potential employers. The Career Center also offers information on internships, career possibilities, and assistance in preparing for job applications and interviews. Pay them a visit!

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<sup>44</sup>[http://www.physics.sunysb.edu/physics/msi\\_intro.htm](http://www.physics.sunysb.edu/physics/msi_intro.htm)

<sup>45</sup><http://www.chalmers.se/masters.html>

<sup>46</sup><http://www.ets.org>

<sup>47</sup><http://www.gre.org/testdate.html>

<sup>48</sup>[http://sbhep1.physics.sunysb.edu/~rijssenbeek/PHY\\_junior\\_senior\\_Advising.html](http://sbhep1.physics.sunysb.edu/~rijssenbeek/PHY_junior_senior_Advising.html)

<sup>49</sup><http://www.oberlin.edu/physics/GRE.html>

<sup>50</sup>[http://physicsandastronomy.vassar.edu/students\\_greprep.shtml](http://physicsandastronomy.vassar.edu/students_greprep.shtml)

<sup>51</sup><http://www.wpi.edu/Academics/Depts/Physics/Majors/gre.htm>

<sup>52</sup><http://www.career.sunysb.edu/>

- The national Society of Physics Students has a web page entitled **Careers using Physics**<sup>53</sup> that provides a great overview of physics career possibilities.
- The American Astronomy Society has a web page with advice for careers in Astronomy.<sup>54</sup>
- The American Institute of Physics maintains a Career Services<sup>55</sup> office with great resources and information, including job listings and resume posting. They also maintain a listing of employment data for physicists<sup>56</sup>. In particular you can see a state-by-state listing<sup>57</sup> of companies that hired Physics Bachelors, with an impressively long listing for New York. They also offer for sale a book *Landing Your First Job: A Guide for Physics Students*<sup>58</sup>.
- The American Physical Society has asked Prof. Chang-Kee Jung (Chang.Jung@stonybrook.edu, room D-141, tel. 632-8108) to be the local liaison person for “professional development” concerns. This means that he has information about employment, and you are invited to ask his advice. Prof. Jung maintains a Career and Professional Development web page<sup>59</sup>.
- Consider teaching physics (see Sec. 4.3)!

#### 4.9.1 Recent graduates in Industry

Each physics major receives a broad education in the physical principles which control our world. Our basic goal is to teach you how to think. Hence, physics majors are often successful in a broad range of industries. The greater the breadth, depth and quality of your education, the more success it will bring. Some example industrial careers chosen by our graduates include:

- Peter Busch, class of 2007, is working for Wells Fargo Financial.
- Ryan Hook, class of 2007, is working for Goldman Sacks.
- Sagar Pilia, class of 2007, is also in the financial industry, working for Bloomberg, L. P.
- Katie Wallace, class of 2007, is in California seeking a career in alternative energy.
- Evan Raba, class of 2007, is working for KM Labs in Colorado.
- Vasilii Khmelenko, class of 2007, is employed as an actuary.

It is also worthwhile noting that Stony Brook PhD recipients have founded technology companies such as Xradia Inc.<sup>60</sup>, and that a number of PhD physicists in our area are employed in the financial sector both on Wall Street and also at companies like Renaissance Technologies Corp.<sup>61</sup>

#### 4.9.2 Recent graduates in Education

There is a great need today for secondary school teachers with training in science, as noted above. Example education careers chosen by our graduates include:

- Tara Newman, class of 1996, received a M.A. in Computers Education from Columbia University. She is currently teaching Regents Physics, AP Chemistry and Honors Chemistry at Hauppauge High School.
- Brian Lenin, class of 2002, is teaching in the New York City Schools, Gifted Students program.
- Jennifer Canera, class of 2003, is teaching High School Science.

<sup>53</sup><http://www.spsnational.org/cup/home.html>

<sup>54</sup><http://www.aas.org/career/>

<sup>55</sup><http://www.aip.org/careersvc/>

<sup>56</sup><http://www.aip.org/statistics/trends/emp trends.htm>

<sup>57</sup><http://www.aip.org/statistics/trends/states/state.htm>

<sup>58</sup><http://www.aip.org/careersvc/resources.html>

<sup>59</sup><http://ale.physics.sunysb.edu/~alpinist/CPDL/>

<sup>60</sup><http://www.xradia.com>

<sup>61</sup><http://www.rentec.com>

### 4.9.3 Recent graduates in Physics Research

Students who hope to become a research scientist or a professor in physics or a related field, should plan on obtaining the B.S. in Physics with Honors. They should attempt to be accepted as a research student (taking PHY 487) by a faculty member as early as possible, perhaps in the junior year. These students should be aggressive in making use of the vast resources available at Stony Brook which can be of great advantage in realizing their educational goals. Example research careers chosen by our graduates include:

- Rita Kalra, class of 2005, received a Churchill Fellowship and is in graduate school at Cambridge University.
- Melissa Friedman, class of 2006, received a Marshall Fellowship, the first to a Stony Brook graduate, and is doing graduate studies at Oxford University.
- Theodore Feldman, class of 2007, is in the graduate Applied Physics program at Harvard (having turned down Oxford!).
- Other members of the class of 2007 are in graduate school in Rensselaer Poly, Montana State, U. Mass., Rochester, and UC Davis.

### 4.9.4 Students choosing careers in other fields

**Astrophysics:** Students who wish to pursue a career in astrophysics often become AST/PHY double majors. They must satisfy the minimum requirements of both programs and then take additional courses in the Earth and Space Science or Physics departments which satisfy their educational goals.

**Physics of Materials:** A student wishing to pursue a career in engineering physics with emphasis on materials science and engineering would, in addition to completing the requirements for the B.S. in Physics, take courses in the Department of Materials Science and Engineering (in consultation with both departments) during the junior and senior years.

**Biophysics:** Students interested in biophysics should talk to faculty in the Department of Physiology and Biophysics in the Health Sciences Center. Some of our physics majors have been accepted into research by these faculty.

**Medical School:** Physics provides solid and well-regarded training for students seeking to enter medical school, provided they also take required courses in biology and chemistry.

**Law School:** Physics is at the heart of many modern technologies, so it is excellent preparation for areas of law including patents and environmental law.