

# Department of Physics and Astronomy

This handbook is intended to inform you as a present or prospective physics major about the opportunities available in the Department of Physics and Astronomy. We hope that you will carefully read this, along with the current College Bulletin, to learn what is expected of a physics major and what opportunities are available. If you have questions, feel free to talk to any of the physics and astronomy faculty.

## I. The Academic Program

### A. The Physics Major

#### 1. *Declaring a Physics Major*

To declare a major in physics, a student must have successfully completed one semester of an introductory physics course (either 131 or 141). Because of the rigor of succeeding courses, the department recommends that students have at least a B-average in the introductory course; students with a lower average who would like to become majors should consult with the chairperson.

To apply for a major, the student must obtain a copy of the "Major Declaration" form from the Registrar's Office. A faculty advisor is chosen, who signs the form along with the department chairperson. Finally, the current ("old") advisor signs the form, which is then submitted to the Registrar's Office.

After declaring a major, students should meet regularly with their advisor to plan programs suited to their needs and interests. In fact, frequent informal meetings with advisors and other faculty members in the Department play an important role in students' academic and intellectual growth.

#### 2. *Requirements for the Physics Major*<sup>1</sup>

The physics major consists of a minimum of **11 courses**, usually five core courses, at least four electives, and two courses of research during the senior year. Students should be aware that most physics courses have mathematics corequisites and/or prerequisites, as listed in the course description. Courses above the 200-level typically require a facility with multivariate calculus.

Specifically, each student majoring in physics is expected to acquire a basic knowledge of classical and modern physics by taking a core sequence consisting of:

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<sup>1</sup> Official descriptions and requirements of the major, minors, and 3/2 binary engineering program are in the *Dickinson College Academic Bulletin*. Please refer to these when planning your path to graduation.

1. 131 (or 141)      Introductory Physics I
2. 132 (or 142)      Introductory Physics II
3. 211                Vibrations, Waves, and Optics
4. 212                Introduction to Relativistic and Quantum Physics
5. 282 (or MATH 171 **and** 262)<sup>2</sup>    Introduction to Theoretical Physics

Students will then select at least four elective courses tailored to their preparation, interests, and goals. At least two of these must be at the 300-level or above:

6. PHYS 300-level or above elective
7. PHYS 300-level or above elective
8. PHYS 200-level or above elective
9. PHYS 200-level or above elective

All physics majors not enrolled in a 3-2 engineering program must complete the senior research sequence 491, 492:

10. 491                Senior Research Seminar I
11. 492                Senior Research Seminar II

Students are also strongly encouraged to take the junior seminar course (392), a half-credit course in the fall that prepares students for the senior research experience, as well as for a National Science Foundation (NSF) Research Experience for Undergraduates (REU) (or other summer research experience), the Graduate Record Examination (GRE), and graduate school preparation. Introductory courses intended primarily for non-science majors, such as Life in the Universe (105), Introductory Astronomy (109, 110) and Meteorology (102), may not be applied towards a physics major. Please see the college course catalog for a detailed description of the courses.

Chemistry 141 is also recommended for physics majors; additional mathematics courses such as Mathematics 262 and 271 are strongly recommended as well as Computer Science 131,132.

### ***3. Frequency of Course Offerings***

#### **Majors' courses offered every year:**

- |         |   |
|---------|---|
| 131/132 | Introductory Physics Sequence (full year)                           |
| 208     | Introductory Astrophysics (typically Spring)                        |
| 211     | Vibrations, Waves, and Optics (typically Fall)                      |
| 212     | Introduction to Relativistic and Quantum Physics (typically Spring) |

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<sup>2</sup> The department strongly encourages all majors to take PHYS 282, as it discusses material relevant to future physics courses that are not covered in the substitute math courses.

282	Introduction to Theoretical Physics (typically Spring)
306	Intermediate Astrophysics (topics rotate)
491/492	Senior Research Seminar Sequence

**Majors' courses offered every other year:**

311	Dynamics and Chaos (typically Fall of even years)
312	Electrodynamics (typically Fall of odd years)
331	Thermodynamics and Statistical Mechanics (typically Spring of even years)
431	Quantum Mechanics (typically Spring of odd years)

**Other majors' courses offered regularly:**

202	The Physics of Meteorology
213	Analog and Digital Electronics
313	Computer Interfacing and Laboratory Instrumentation
314	Energy and Environmental Physics
315	Physics of Medical Imaging
361	Topics in Modern Physics (topics rotate)
412	Advanced Electrodynamics and Plasmas

**Other courses offered every year:**

109	Introductory Astronomy (Planets and Solar System)
110	Introductory Astronomy (Stars and Galaxies)
141/142	Physics for the Life Sciences
392	Junior Seminar

***4. Typical Major's Schedule***

Most physics majors begin their study of physics in the first year, although some begin in the sophomore year. A typical schedule is shown below for each situation. All courses listed are strongly suggested for students planning to attend graduate school. Students interested in graduate study in astronomy or astrophysics should include Physics 306 in their program.

*For students who complete introductory physics in their first year:*

<b>Class Year</b>	<b>Fall Semester</b>	<b>Spring Semester</b>
<b>First Year</b>	Physics 131	Physics 132
	Math 170 (See note.)	Math 171
	First-Year Seminar	Language or Distribution
	Language or Distribution	Distribution or Elective
<b>Sophomore</b>	Physics 211	Physics 212
	Physics Elective	Physics 282
	Math 270	Distribution or Elective
	Distribution or Elective	Distribution or Elective
<b>Junior</b>	Physics 300-level course	Physics 300-level course
	Physics Elective	Physics Elective
	Distribution or Elective	Distribution or Elective
	Distribution or Elective	Distribution or Elective
<b>Senior</b>	Physics 392 (half-credit)	
	Physics 491	Physics 492
	Physics Elective	Physics Elective
	Distribution or Elective	Distribution or Elective
	Distribution or Elective	Distribution or Elective

*For students who complete introductory physics in their second year:*

<b>Class Year</b>	<b>Fall Semester</b>	<b>Spring Semester</b>
<b>Sophomore</b>	Physics 131	Physics 132
	Math 170 (See note.)	Math 171
	Distribution or Elective	Distribution or Elective
	Distribution or Elective	Distribution or Elective
<b>Junior</b>	Physics 211	Physics 212
	Physics Elective	Physics 282
	Math 270	Distribution or Elective
	Distribution or Elective	Distribution or Elective
<b>Senior</b>	Physics 392 (half-credit)	
	Physics 300-level course	Physics 300-level course
	Physics 491	Physics 492
	Physics Elective	Physics Elective
	Distribution or Elective	Distribution or Elective

**Note:** A student taking Math 151 in place of Math 170 should try to take Math 171 in summer school, particularly if starting physics in the sophomore year.

## ***5. Discussion of Senior Seminar Expectations***

The Senior Seminar course (Physics 491 and 492) is designed to be the capstone experience for physics majors, in which they use skills developed throughout the major on a variety of projects. Although the particular course instructor may have additional expectations, a brief description of the primary aspects of the senior seminar are described below.

### **a) Senior Research Project**

Students have two options for their senior research project:

- 1) To participate in the capstone-project, for which one or two faculty members have developed a year-long set of connected projects;

**OR**

- 2) To propose and participate in an independent research project that will be advised by another faculty member.

The default is option 1. To qualify for option 2, you must “opt out” of the capstone project by submitting a proposal that describes an independent project that you will undertake. The proposal should be prepared in consultation with the proposed research advisor and must be approved by the faculty. The proposal is due by the last day of classes during the spring semester of the student’s junior year. Only after this proposal is approved by the entire faculty will you be able to undertake an independent research project. Note: a senior not participating in the group capstone-project is still expected to meet with all other seniors for Physics 491 and Physics 492.

### **b) Senior Exam**

The other major activity during the senior year is the Senior Exam. This is an exam that covers material from the five required lower-division courses (131, 132, 211, 212, 282). It is expected that every senior will pass the Senior Exam with adequate preparation (a passing score is generally around 60% or perhaps a bit lower). The preparation for this exam will be mainly up to you. To help prepare you for this exam, we will provide copies of exams from the previous several years. We recommend that you work through the problems on these exams and consult resources to review material as appropriate.

The exam will be given to all seniors, typically early in the fall semester. It is therefore beneficial to begin preparing BEFORE returning for the fall semester. The actual timing of the exam and how it will count toward your 491/492 grade will be provided by the 491/492 instructor(s). As noted below, to obtain Departmental honors, students must score sufficiently well on the Senior Exam in

the fall of their senior year.

### c) **Written and Oral Communication**

Being able to communicate your research is an important skill that is developed over the course of the entire major. For the senior seminar, majors will be expected to discuss their work both informally and formally: informally to other seniors during the weekly meetings of the Senior Seminar, and formally to the public in talks in both the fall and spring semesters. In the spring semester, seniors will present their research in written form to their research advisor and to the instructor of the Senior Seminar, as well as give a poster presentation at the Dickinson Science Research Symposium.

## 6. *Honors in Physics*

Honors in Physics is a special recognition given to students who have successfully completed distinguished research in the senior year. Students who wish to graduate with honors must normally complete a research program through the following steps:

1. In consultation with the sponsoring faculty member, submit a proposal for honors prior to the last day of classes during the fall semester of the senior year.
2. Score sufficiently well on the Senior Exam during the fall term (this will typically require a higher score than the cutoff for passing).
3. Have a minimum 3.30 GPA in Physics.
4. Complete a final honors thesis (research paper), with copies submitted to all faculty members in the Department by the last day of classes of the spring semester.
5. Make an oral presentation of the work at a professional conference during the spring semester (please consult with faculty members for an appropriate venue).
6. Present the results of the research orally before the Department faculty at a designated time after the end of classes in the spring semester.

## B. The Physics Minor

A physics minor is expected to acquire a basic knowledge of classical and modern physics by taking six of the Department's course offerings:

1. 131 Introductory Physics Sequence I
2. 132 Introductory Physics Sequence II
3. 212 Introduction to Relativistic and Quantum Physics
4. PHYS 200-level or above elective
5. PHYS 200-level or above elective
6. PHYS 200-level or above elective

**Special note to Astronomy Minors:** The three elective courses used to fulfill the requirements of a minor in physics may **not** be double-counted to fulfill the requirements of an astronomy minor.

## C. The Astronomy Minor

An option is available for students who wish to add an astronomical perspective to a major in any field. The astronomy minor consists of the following six courses:

- |                 |   |
|-----------------|---|
| 1. 109          | Intro. Astronomy (Planets and Solar System),                    |
| 2. 110 (or 208) | Intro. Astronomy (Stars and Galaxies) (or Intro. Astrophysics), |
| 3. 306          | Intermediate Astrophysics (topics rotate),                      |

**and**

three regularly offered courses, independent study, independent research, or internship credits offered by the Department of Physics and Astronomy. One of these courses/experiences may, upon prior approval by the Department, be offered by another department or be an external experience such as a summer Research Experience for Undergraduates. No more than three of these courses or experiences may count toward both the physics major and the astronomy minor.

## D. The 3/2 Binary Engineering Program

The 3/2 Binary Engineering Program is a five-year program consisting of three years at Dickinson and two years at one of three engineering schools: Case Western Reserve University, Columbia University, or Rensselaer Polytechnic Institute. Upon successful completion of both portions of the program, students receive the B.S. degree from Dickinson and the B.S. in engineering from the engineering school. For a complete description of the program, please see the *Pre-Engineering* section of the *Academic Bulletin*.

Note: a student must complete the Dickinson distribution requirements and requirements for a major field of concentration during the three years at Dickinson. Students must begin the major field of concentration in the first year. Courses taken at the engineering school to complete

Dickinson requirements must be approved before leaving Dickinson. This program takes significant advance planning; please consult the *Pre-Engineering* advisor as soon as possible during your first year.

## **E. Independent Study and Independent Research**

Independent study and research is strongly encouraged by the department. Independent research projects are readily available in several areas of continuing laboratory research including astrophysics, plasma physics, non-linear dynamics, and optics. Independent research students have often published papers and/or given talks at physics and astronomy meetings. Students planning on graduate study are encouraged to do independent research during their college career, in addition to the required senior research 491, 492.

## **F. Summer Opportunities**

### ***1. Summer Research***

Upper level physics majors are strongly encouraged to apply for summer research opportunities in this department or elsewhere. Many of these positions are funded by the federal government or other sources. Specifically, the NSF's REU program has numerous positions at a variety of institutions across the country.

### ***2. Summer Internships***

A number of internships are generally available for both summer and academic year work. Recent internships arranged through the Dickinson College Internship Office have included work with a variety of local high technology industries, with a health physics unit at local hospital, and a summer internship at a NASA research facility. In addition, a physics major may complete an internship for an entire semester at a government or private laboratory.

## **G. Study Abroad**

Several physics majors have included study abroad (for one or two semesters during the junior year) as part of their programs in physics. Students have studied in Germany, France, and Australia, and programs are available in other countries. When studying abroad, special planning is essential to ensure all requirements of the major will be met. Please consult with your advisor as early as possible.

## **II. Job Opportunities**

A variety of job opportunities exist in the Department for students. These may include teaching or research assistant jobs, working in the help room in the evenings, assisting in the planetarium or observatory, and working with various grant projects. Some of these opportunities involve summer work. Potential jobs are listed below – please note that not all jobs are available in all semesters/years.

### **A. Physics Course Assistants**

#### **1. Introductory Physics Courses**

##### a. Classroom Assistants

Must attend assigned section of Workshop Physics (calculus or algebra based course). Must review Activity Guide notes before each class meeting. During class meetings help students with workshop activities and with computers. Classroom assistants may be asked to determine and record Activity Guide completion scores, return and collect homework assignments, and duplicate and distribute class-generated data. Must be willing to attend weekly preparation meetings to be scheduled at the start of each semester.

##### b. Homework Graders

Read the solutions sets provided by faculty, reviewing the appropriate physics topics if necessary. Read each student homework set and score each problem. Graders are expected to work independently and exercise discretion, but should consult with Workshop Physics faculty coordinators if a significant ambiguity arises. Must record homework scores and keep back up copies of such records.

##### c. Introductory Room Consultants

Must open Tome 101 or 103 at the start and close and secure the room at the end of their shift. Before leaving the room, Consultants must turn off LabPro's, check that battery powered equipment (such as DVM's ) are turned off, clean up stray papers and items, erase white boards, turn off lights, make sure that audio and video equipment is turned off, and the doors and drawers of the front cabinet are locked, and lock the room. During their assigned times, Consultants help students with physics homework problems, and with the completion of Workshop Physics activities and projects. Must therefore review Workshop Physics homework assignments.

#### **2. Upper-Level Physics Courses**

Teaching Assistants have been used in upper-level courses including Physics 212, 213 and others.

## B. Astronomy Course Assistants

### 1. Introductory Astronomy Courses

Must consult with instructor and review laboratory activities before each lab meeting. Must attend lab meetings. During lab meetings help students with lab activities and with computers.

### 2. Introductory Astronomy Grader

Must consult with instructor and review laboratory activities before each lab meeting. During lab meetings help students with lab activities and with computers. Must consult with instructor after each lab regarding scoring policies. Must score labs, record scores, maintain backup records, and return labs in a timely fashion.

### 3. Planetarium Assistant

Must create and run planetarium shows. Must consult planetarium director about planetarium maintenance, show development, show programming and open houses.

### 4. Observatory Assistant

The primary duties of Observatory TA's are to show the constellations to students in Introductory Astronomy, administer Keller-plan "Constellation Quizzes" until students are familiar with the sky, open and operate the small telescopes for Introductory Astronomy students and safely store and close the telescopes. Must consult with instructors and review any outdoor laboratory activities to be carried out by Introductory Astronomy students, and must assist in those activities.

## C. Other Job Opportunities

1. Office Assistant: One student is generally hired each year to assist in the Tome Hall Academic Department Coordinator. This position should be filled by a student on Work-Study, and it may be filled by a non-physics major.
2. Research Assistant: Students may be hired as research assistants if funds for such positions are available. Students on financial aid may apply for any Dana Internship that is offered in the Department. Those wishing to apply for Dana Internships should contact the Financial Aid Office at the time the internships are announced.
3. Tutors: A student who has completed the introductory course with a grade of B or higher may apply to be a tutor. Those interested should contact the chairperson during the first two weeks of the fall semester. The Associate Dean's Office does the actual hiring, but requires the recommendation of the physics faculty member.

### **III. Clubs and Organizations**

#### **A. Society of Physics Students (SPS)**

The Society of Physics Students (SPS) is the local chapter of the national organization. SPS holds meetings to inform students about careers in physics and happenings in the Department, and organizes picnics for students, faculty, and staff. SPS helps in identifying and contacting colloquium speakers. Any student may be a member of the physics club with no dues. To be a member of SPS, a student must pay \$15 dues each year to the national organization. Each SPS member receives a subscription to *Physics Today* and a periodic SPS Newsletter. Members may also get subscriptions to various scientific magazines at reduced rates. Members receive significant reductions in conference registration fees.

#### **B. Sigma Pi Sigma ( $\Sigma\Pi\Sigma$ )**

Sigma Pi Sigma is the honorary society for physics students. The faculty members select candidates in the early fall of the academic year. In order to be considered for election, a student must by the time of selection:

1. have a 3.30 or better average GPA in physics courses that count toward the major,
2. have completed three courses in physics at the 200-level or greater,
3. have senior-class standing at the college,
4. be in the upper third of his/her college class, and
5. be active in the Department.

The reception for those selected takes place in the fall of each year. *After* the reception there is an invited talk and dinner. A membership fee of \$45 is required to become a member of  $\Sigma\Pi\Sigma$  (only \$25 if the student is already a member of SPS); there are no dues after the initial fee. However, members will regularly be invited to make a donation to keep the program funded.

#### **C. Astronomy Club**

Astronomy Club is a student-run, Student-Senate funded organization devoted to enjoying astronomy and sharing it with the Dickinson and Carlisle communities. The club hosts monthly open houses which include a planetarium show and stargazing with the club's telescopes and the observatory on the roof of Tome. Club members also take a couple of field trips each semester, including an annual trip to the Black Forest Star Party in Cherry Springs National Park, Pennsylvania. Club members plan and give monthly planetarium shows and observatory open house events for the College and Carlisle communities, as well as carry out a number of public outreach activities. Astronomy Club meets one evening each week before enjoying a dinner in

the Caf like a nice big happy family.

## **IV. Student Rights and Responsibilities**

Being a physics major involves some responsibilities.

- A. Keys and Building Security: A student who has declared a physics major is eligible to have keys the majors' room. Additional keys may be loaned to students as needed for research, independent study, and departmental employment. There is typically a \$10 deposit on keys; once the key is returned, the student will get back her/his deposit.
- B. Majors' Room (Tome 208): During the designing of Tome Hall, physics majors successfully lobbied for a room of their own, where they might study, store a few personal items in lockers, and relax. The Majors' Room is this room. It is the responsibility of all majors to keep the room in presentable condition. Majors are reminded that this room is still officially a classroom and that it may be used as such any time in the future. The continued use of the room by majors is dependent upon students keeping it clean and orderly.
- C. Attendance at colloquia: Physics majors are expected to attend all department colloquia. Attendance is recorded, and the student's attendance record may be reflected in course grades (as noted in syllabi) and mentioned in evaluation letters written by faculty members.
- D. Departmental Service: Majors are strongly encouraged to contribute to the Department (and their own education) by working as student assistants or graders in courses they have completed. Other employment opportunities are listed elsewhere.

## **V. Departmental Research Facilities**

The Department of Physics and Astronomy has several well equipped laboratories for students to use for independent study and research. The laboratories are also used as part of ongoing faculty research.

### A. Observatory (Tome roof)

The Michael L. Britton Memorial Observatory, on top of the conical structure adjacent to the Tome Science Building, consists of a 24-inch Ritchey-Chrétien telescope with an Apogee AP7 512 x 512 charge-coupled device (CCD) camera. The CCD comes equipped with UBVRI filters and is used for imaging and multicolor photometry of variable stars and asteroids. The telescope supports student/faculty research and gathers synoptic observations that can provide data for student projects.

### B. Astrophysics Research Laboratory (Tome 214)

One of the many ways to learn about the nature of the universe is to study light from distant objects. The astrophysics research lab has computers dedicated to astrophysics

research, astronomy journals, and astrophysics reference materials. Dickinson is a member of the National Undergraduate Research Observatory Consortium. Students have accompanied professors to NURO to study stars, galaxies, asteroids, and other objects. At Dickinson, students analyze the data from NURO, the Britton telescope, or other observing facilities.

C. *Plasma Laboratory (Tome 104)*

The study of plasma, a hot, dense ionized gas, is of interest in astrophysics and as a possible source of energy in the next century. The Dickinson Plasma Lab is equipped with two vacuum chambers, each with a set of large electromagnets capable of producing a 1 kilogauss magnetic field to confine a plasma. Presently, research efforts focus on basic plasma physics processes in a plasma propulsion device known as a Hall thruster. This thruster was designed and built in our own machine shop. Every year one or two physics majors complete their senior research project in the plasma lab. Several Dickinson alumni have later obtained PhDs in plasma physics.

D. *Optics Laboratory (Tome 207)*

The Optics Lab has a femtosecond, titanium:sapphire laser system for studying a variety of atomic and molecular phenomena. Current projects involve optical pulse shaping and using the laser as a tool for multiphoton imaging of biological systems. In addition, the lab has a number of supporting lasers and equipment for other projects.

E. *RF/Microwave Laboratory (Tome 204)*

In the radio frequency (RF) and microwave lab we study the interaction of nonlinear media with electromagnetic waves in the radio- and microwave frequency range. Magnetically ordered crystals are subjected to microwaves in order to induce and study certain magnetic instabilities. Electrical lattices driven by RF-signals are also investigated experimentally. Again, instabilities are induced which can lead to interesting spatio-temporal patterns. For both systems, computer simulations complement the experimental data.

F. *Patterns Laboratory (Tome 209)*

The Patterns lab investigates pattern forming systems. Typically, magnetic liquids (*ferrofluids*) are placed in applied magnetic fields and the resulting ferrofluid evolution is captured using a video camera. Projects typically involve experimental, theoretical, and computational components. Another recent project involved collapsing soap bubbles and the exploration of soap films in applied electric and magnetic fields is an interesting extension.

## **VI. Other Departmental Facilities**

### **A. Planetarium**

The Charles M. Kanev Planetarium in Tome Hall is equipped with a computer-controlled Spitz System 1024 projector. Planetarium programs are produced with substantial student participation for the college community, local schools and the general public. Show content engages the physical universe, while reflecting global fascination with the heavens above. Topics include the seasonal appearance of the sky and cover the attempts of humankind to understand the universe surrounding them from prehistoric megaliths aligned to the heavens to the latest gleanings from space technology about the structure and evolution of planets, stars, galaxies and the universe itself. For more information, see Professor Morgan, the planetarium director.

### **B. Machine Shop**

The Physics and Astronomy machine shop located on the first floor of Tome Hall is open Monday through Friday, from 8 am to 4 pm for all your design, machining, welding, and woodworking needs. Individualized machine shop and welding lessons are available on a first come, first served basis. For more information see Tonya Miller in Tome 201 or call x1413.

## **VII. Post-Dickinson**

Dickinson graduates with a B.S. in Physics have skills and experience that are valuable to society in many ways. The opportunities are quite broad, including areas such as engineering, environmental science, high school teaching, financial advising, medicine, and law. Here we discuss in more detail three potential routes. A list of former Dickinson physics graduates and their professional activities appears in the Appendix at the end of this handbook.

### **A. Graduate School**

Physics majors who decide to pursue post-secondary education typically receive M.S. or Ph.D. degrees in physics, astronomy, or other related fields such as applied physics, chemistry, electrical engineering, environmental science, mechanical engineering, and meteorology. Advanced degrees in these fields may lead to employment in academic, government, or industrial settings. Students wishing to use their physics background directly in research or college level teaching are advised to work toward an M.S. or PhD degree in physics or a related field.

Students interested in attending graduate school are strongly encouraged to begin the preparations and process as early as possible during their career at Dickinson. Specific suggestions include:

1. **Take as many Physics and Astronomy courses as possible.** A broad exposure to many areas of physics is excellent preparation for graduate school and the GRE, and it may help you discover an area of physics that you would like to study further.
2. **Take the Junior Seminar Course.** Junior Seminar (PHYS 392) is a half-credit course

offered in the fall semester of the junior year that prepares students for their senior research experience. In addition, the course offers assistance in finding and successfully applying for a summer REU program, studying for the GRE, and graduate school applications.

3. **Seek out additional research experiences.** Even before the Senior Research Seminar (PHYS 491/492), there are a variety of ways to engage in research as an undergraduate. A summer research experience (either at Dickinson or through an outside REU program) is probably the best way to prepare for graduate school. You get an experience of what life in the lab (or in front of a computer) is like, it looks very good on your graduate school applications, and your advisor can typically write you an excellent letter of recommendation (see more on recommendation letters below!).
4. **Apply for Graduate School Fellowships.** The National Science Foundation and other organizations sponsor fellowship programs for graduate students in the sciences. These fellowships allow you to concentrate on classes and research in grad school since you will not need to work as a teaching assistant. They are quite prestigious and typically provide larger stipends than you would receive otherwise. Application deadlines come up quickly, so be sure to look early! Please contact Professor Morgan if you are interested.  

A word on how funding is typically handled for graduate school in physics. Most schools provide “full funding” for accepted Ph.D. students, including paid tuition, a monetary stipend (enough to live on, but not in luxury), and some form of health insurance. This funding is provided via three different mechanisms: Teaching Assistantships (TAs) where you teach undergraduate laboratory sections, Research Assistantships (RAs) where you work in a research lab (usually of your choice), and Fellowships (where no extra work is required). Both TAs and RAs are expected to work approximately 20 hours per week. Incoming students are usually offered TAs (or Fellowships if their academic record is very strong). As you progress in your career, you find an advisor whose lab is (hopefully!) able to provide an RA for your thesis research. Note that the NSF and other outside fellowships are separate from any financial support you will be offered by your graduate school.
5. **Take the GRE.** Those planning on enrolling in graduate school in physics or a closely-related field should plan to take both the General and Physics Graduate Record Examinations. Although these are offered at various times throughout the year, advance planning is necessary. The GRE physics exam should not be taken without preparation! The Educational Testing Service and independent publishers have published helpful GRE study guides for both the General and Physics portions.
6. **Apply to Graduate Schools.** The next step is to identify graduate schools that are appropriate to students' particular abilities and interests. The American Institute of Physics (AIP) has guides to Graduate Programs in physics, located in the physics office. Graduate school catalogues and flyers are available from the department as well. Consultation with the physics faculty and former students now attending graduate schools for ideas on appropriate schools can be very valuable. Once the list is narrowed to 10 to

12 possible schools, further information from the schools should be requested.

It is normal to apply to at least five schools, including two the student is confident will offer acceptance. Some application deadlines are as early as December, so students should begin the process early in the fall semester. You will usually be invited to visit (at the school's expense) the schools that offer acceptance over a "new student weekend." This is an excellent opportunity to learn more about the school and meet the current and future students.

7. **Ask for Recommendation Letters.** In general, reference letters will be required from at least three faculty members and/or research advisors. Those people who have had contact with you both inside and outside the classroom are best able to write effective letters of recommendation. Providing at least two weeks notice before any deadline is expected. Each faculty member should be provided with the appropriate forms and/or instructions, as well as stamped, addressed envelopes in which to mail the recommendations (if they are to be mailed).

## B. High School Science Teaching

There is a strong demand for well-qualified high school science teachers (especially in physics), and many people find teaching to be an extremely rewarding career. Certification is required to teach in public schools (although not for some private schools), and students wishing to pursue a career as high school physics teachers should contact the Education Department at Dickinson as early as possible. A prospective teacher should gain as much laboratory experience as possible and work as a teaching assistant in the introductory physics courses for at least two years.

## C. Entering the Workforce

Students interested in seeking employment immediately after graduation should find that a physics B.S. degree qualifies them for entry level positions in industrial or government engineering, technical sales, and a host of other technical fields in which communication and analytical problem solving skills are important. The College has a well staffed career center that can help students locate companies interested in hiring physics majors. The career counseling office also provides assistance in writing resumes and filling out applications. In addition, the faculty in the Department may be a good resource when deciding on a career. The faculty have contacts with physicists and astronomers in many areas who may be able to provide help in exploring career opportunities. For more information, students should also consult the AIP website, which has lists of physics-related careers.

## **Appendix A: History of the Department**

### **Physics at Dickinson**

Science courses were first taught at Dickinson College in 1785 by a Professor of Mathematics and Natural Philosophy. Dickinson became one of the first colleges in the nation to use demonstration apparatus in the teaching of science. In 1808 Benjamin Rush directed the purchase of a static electricity machine, an air pump and a hydro-pneumatic blow pipe. The famous Joseph Priestley laboratory apparatus was purchased in 1811. Some of the Priestley Apparatus is on display in the College's May Morris Room, while some is now held by the Smithsonian Institution.

The place of the sciences at Dickinson was given new prominence in 1865 when Charles Himes was appointed as Professor of Natural Science. Himes' most profound contribution to Physics at Dickinson was the planning and fund raising for the original Tome Scientific Building (now the Stern Center), which was completed in 1884. Professor Himes' many hallmarks included the development of more laboratory work in the sciences and the requirement that students read not only textbooks but current journals in the advanced courses. In 1876 Himes introduced "Experiments in Physics" and "Experimental Lectures by the Students" into the senior curriculum. This precursor to our present senior seminar ranks Dickinson as one of the first colleges in the nation to stress research in the undergraduate curriculum. The Department has had a distinguished history, inspired by Himes' dream (expressed in his dedication speech for the Tome building) that Dickinson might contribute to the advancement of science in addition to being a place where one studies the advancements of others.

### **A New Home for Physics and Astronomy**

The Department argued for expanded teaching space, new laboratory space, and the inclusion of both a new planetarium and research grade observatory in the plans for the new building, originally simply called "the NSB." A committee of students, faculty and administrators was formed to help steer the project. The committee began to map out the contents and arrangement of the new building.

Student input was crucial to every aspect of the design of the new building. For example, the layout of the storeroom for introductory physics equipment was largely done by physics majors. Students also planned the 'informal seminar room' (the major's room) and helped investigate equipment options for the new planetarium. In fact the building was designed in true Dickinson fashion with inputs from the entire College community. Dickinson physics majors gave selflessly of their time and energy, most knowing that they would graduate before the new building was completed.

The Department moved into the new building in the fall of 1999; the planetarium and the observatory were completed the spring of the next year. It is our hope that all our alumni from years past and from years in the future, will see the "NSB", renamed in recent years first "The Tome Scientific Building" and then "Tome Hall" will in fact know that our new building is still Tome Sweet Home.