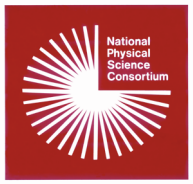

The National Physical Science Consortium

Graduate Fellow Student Handbook

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Welcome

Dear NPSC Fellow:

If you are a new Fellow**,** CONGRATULATIONS on your successful candidacy to the highly coveted NPSC fellowship program. Your ability to qualify for an NPSC Fellowship is testimony to your intellectual talents, the remarkable personal efforts you put forth as an undergraduate student, and the faith and confidence your former professors have in your academic future. The NPSC staff is proud and happy to welcome you. Your selection means a new and rare door of opportunity has been opened to help you to prepare for national leadership in science and industry. You can play a unique role in the future to keep your country scientifically and economically strong and healthy. You should realize as you begin your graduate studies, there are no "a priori limits" set on your possibilities. Achieving a bachelors degree in science and qualifying for a prestigious graduate fellowship already demonstrate your aptitude to achieve goals. You are now on the threshold of attaining even higher levels of accomplishment! Selection to this fellowship program means you are one of the nation's brightest scholars. Like previous NPSC Fellows, you are expected to play a leading role in shaping the overall future of this country in the next few decades. This is a great honor and responsibility. As you progress, the NPSC staff is ready to lend you support throughout your educational endeavors.

If you are a returning Fellow, CONGRATULATIONS on your progress to date. We always like to hear from you—so please drop NPSC a note (e-mail or regular), to let us know how you are doing. Remember to keep us apprised of your address, telephone number, or e-mail address change. We would also like to know if there is a special event on the horizon in your life this coming school year. For the e-mail address, telephone number, and mailing address of NPSC staff, see the NPSC website.

Whether you are a new or returning student, we hope you will find this handbook to be practical and useful in the course of your studies. We urge you to reflect on these suggestions and add these ideas to your own repertoire of useful graduate training techniques. These thoughts are the result of our experience with issues affecting NPSC Fellows at various universities over the past few years. They also reflect the input NPSC Fellows gave in a confidential survey. Our goal is not only to help you optimize your chances to do well throughout your studies, but also to keep your overall graduate school experience positive by addressing some issues of concern.

If you are new, this handbook contains not only ideas on what to expect during your first two years in graduate school, but also provides tips on how to successfully deal with some issues involved. The first two years of graduate school are extremely important if you are to remain on a degree candidacy track. Much of what is discussed will be things you need to know during those first two years. Successful passage through this phase of your training will ensure candidacy to a degree and also success in research and thesis activities as well.

If you have already spent a year or more in graduate school, you may no longer have to face issues similar to those facing incoming students. However, you will find in this document, useful information of general interest, including issues which are particularly relevant to senior graduate students.

The key to a successful graduate experience is to learn to anticipate and prepare for situations and issues that are most likely to shape your intellectual destiny. You need to recognize situations that require initiative and action on your part to achieve your goals. In other words, be proactive rather than reactive.

If you can't handle it on your own, ask for help. Although you are expected to assume personal responsibility in matters that affect you, NPSC staff are anxious to assist when you decide to seek help. Specific examples of situations that require communication with the NPSC's office are discussed in this handbook. The key word to keep in mind is communication.

As an NPSC Fellow, your academic training depends on three essential relationships:

Your relationship with your new academic department;

Your relationship with your sponsoring employer; and

Your relationship with the NPSC office.

You need to open communications with the NPSC office and representatives of your academic department, particularly your academic advisor. Initiate contacts with your sponsoring employer when dealing with matters that concern your obligations to the employer. In the next few pages, we will discuss the nature and the importance of these relationships, and make suggestions on how to best utilize them. (Refer to your contract and appointment.)

In terms of professional goals, your relationship with your new department will have a lasting impact on your future. Any action taken which might affect your relationship with your department must be given careful advance thought. In particular, expect that any action you take counter to your department's advice could impair your relationship with the department. Keep in mind that while both NPSC and your sponsoring employer are supportive of you now and in the future, the support you get from your department will, in general, become stronger as they know you better and interact with you.

Your admission to a graduate program does not guarantee candidacy to a graduate degree. All new students must meet certain eligibility requirements for graduate degree candidacy. The department/graduate program requires that entering students demonstrate ability and potential to successfully handle academic responsibilities at the graduate level, before the program will commit to the student. To become a successful graduate student during your first two years you must meet certain criteria set by your graduate college and/or by your new department. Each school has its own set of criteria. Most criteria used by the department to determine your immediate status can be met by the end of the second year. This is one of the many reasons your first two years are critical.

Verify that your status as a degree candidate has been established by the end of your second year. One of your first priorities, after arriving on campus, is to discern the department requirements for a degree candidacy track. Once you understand the expectations, formulate your academic plans to optimize your qualification chances. A sensible academic plan includes a careful selection of courses, a realistic schedule to prepare for qualifying exams, and an interest in finding an appropriate research topic.

One of the objectives of this handbook is to help you get the most needed information as soon as you arrive at your new school, in order to prepare ahead of time, and give yourself the best chance to advance toward your degree without undue delays.

Fellow to Fellow:

The fellowship which we have received is one which provides us financial security throughout our graduate program, a comforting freedom. It is also an acknowledgment of our outstanding achievements so far. However, the consortium goals go beyond just doling out stipends as an award. The NPSC is also an invaluable resource for communication, support, and networking. The Handbook was put together with this in mind. The hope is that it will provide continuing assistance to help us avoid obstacles that make an already challenging period together tougher. When a group of us gathered to participate in the meeting, we went through the draft carefully, spending hours discussing the type of information and support we would like and wish we had earlier. The result is a collection of advice and insights drawn from our collective experiences which we agreed were crucial to share with you. Please take the time to read it, and, if you still have unanswered questions, write to NPSC for clarification.

Good Luck!
Laura J. Lising, NPSC Fellow
University of California, Berkeley
Sponsor: National Security Agency

Before Registration

Your Sponsoring Employer and the World of Work

Your NPSC fellowship would not be possible without the commitment and support of your sponsoring employer. Whether your sponsor is a private corporation or a governmental agency, their continued support is vital to your future.

Your employer provides your stipend and a minimum of two summers of paid employment, transportation to and from the location of your summer employment, and a mentor.

The NPSC sponsoring employer member agrees to do this for a variety of reasons. First and foremost, they believe in the NPSC's mandate to provide the opportunity for underrepresented minority and female physical science students to complete their graduate education. These employer members also look to the future. In planning how to best fill their needs for the next generation of research scientists—they look to you to fill that gap.

During the two required summers of employment, you will be doing valuable research, and will become part of the world of work. You must be aware of certain things to make this experience both successful and rewarding.

Your employer will assign you a mentor. This person can be a valuable asset. Mentors are usually long term employees who have a good grasp of how the company or agency works. Avail yourself of this rich source of knowledge and experience.

All employers expect a certain level of on-the-job behavior. The items listed below are basic to any job and should be taken seriously.

1. Be on time to work and work the full shift.

2. Do not overextend break or meal periods.

3. Wear proper clothing and use all required safety equipment.

4. Do not become isolated; become part of a team.

5. Show that you have an interest in the work being done.

6. Ask questions. Respect the opinions and instructions of those in charge of the project.

7. Act in a friendly and helpful manner.

8. Secure the employer's consent prior to scheduling classes, meetings, or vacations.

Your employer has a personal and vested interest in you and your education. It is imperative that you maintain contact with your employer, your job site mentor, and those with whom you worked during the summer. It is recommended that at the end of each semester you write to them. Describe your academic progress and the research you are doing. This courtesy will go a long way in assuring you of your sponsor’s continued support and could be important in your search for either a post-doctoral position or employment.

Visit Your Prospective School

You should visit your prospective or accepted school and meet potential advisors/mentors/graduate advisors, etc., as well as university staff and senior graduate students. An alternative to an actual visit is e-mail communication. This contact will assist you in getting information you really want—as well as other information you need. Develop a checklist of questions for each university. Chapters 1, 2, and 3 should give you checklist ideas and standard questions will enable you to make the best possible decision.

After selecting your university, follow their graduate student registration procedures. Utilize all available resources offered by the department and university staff. In addition, refer to this handbook which outlines in some detail some important facts, information, and suggestions that will make a smooth transition to graduate school.

Your Academic Advisor

All fellows must have an advisor. If you have not been assigned an advisor prior to your arrival at the university, it is urgent that you contact your department chairperson and request one. Your advisor must be a faculty member within the department. It is important that you know your advisor's complete name, office location, office hours, and telephone number in order to request a meeting prior to registration. If you have difficulty in being assigned an advisor, notify the NPSC Executive Director at once.

One of the hallmarks of the NPSC fellowship program is the joint commitment by universities to provide advisors and mentors. Mentoring is discussed in the next segment of this chapter.

As a first step toward a lasting and pleasant relationship, establish a working relationship with your advisor. At your first meeting, be prepared to discuss various aspects of the graduate program. In addition to any questions you might have, we list some critical areas that require immediate attention prior to registration. Also listed are issues that you need to discuss with your advisor at a later time, or during various stages of your work. Keep in mind that over the course of your studies you may need to change advisors.

Review undergraduate/graduate records prior to registration.

Determine courses to be taken during the ensuing academic year (by course numbers, pre-requisites if any, eligibility based on past academic records, number of hours, etc.).

Obtain assistance in scheduling in order to meet degree requirements.

Schedule first-term courses, etc.

Develop a "map" or plan for how you will reach your Ph.D.

Set realistic goals, expectations, and timetables.

Arrange future conference times.

Formulate and implement research plans.

Your advisor should also:

Provide adequate supervision and monitoring for

- Course work
- Research activities
- Thesis writing and defense.

Serve as your advocate in confidential faculty meetings.

Promote all phases of professional development through various activities of enhancement.

Provide leadership and guidance through professional activities, employment, etc.

Your Mentor

Mentors can make a difference in your progress. An effective university mentor makes your transition to the university and to your department a pleasurable experience, especially if she or he is someone to whom you can speak about personal and non-academic matters that could affect your academic work. Your employer mentor is also a great resource for you throughout your graduate career.

As a signatory member of NPSC, each university is obligated to assist fellows in finding a mentor. It is your responsibility to request a mentor. You are urged to exercise that option early as one possible means of ensuring success. While it is your responsibility to ask the graduate chairperson to assist you in finding a mentor, if they are unable to do so, you are expected to contact the NPSC Executive Director to assist you. The NPSC will work within the framework established in the founding charter that the university will provide a mentor to the fellow. Information on NPSC's mentoring philosophy is given later in this document.

Initially, a mentor can help you build constructive relationships with your advisor and faculty. A partial checklist of concerns that should be addressed and acted upon is listed below. Check off each one after you have taken appropriate action:

All undergraduate/graduate courses have been evaluated by advisor prior to attempting more advanced courses.

Course selection and scheduling has been advisor-assisted.

Department orientation was completed prior to registration.

A comprehensive map and timetable has been developed that will lead to your Ph.D.

Appropriate introductions have been made to chairperson, advisor, faculty, staff, mentors, and other graduate students.

Mutual respect and cordiality formulate a basis for communication and programmatic learning.

Allot time for on-going efforts to establish and cultivate peer relations.

Allow time for cultural and social activities.

Manage to be proactive rather than reactive.

Orientation

Your orientation to graduate school and your program of study is essential to your success. Begin your search for information by contacting your departmental secretary. The school and department will conduct orientations. In preparation for academic planning, you will need to find answers to the following questions:

Candidacy track requirements (what is required for you to be on track):

Is a number of credit hours required? If so, what is it?

Can undergraduate courses taken by a graduate student be credited?

What minimum GPA is required of a student to remain on a regular status?

How many credit hours can be repeated to upgrade a deficient GPA?

How and when is your committee scheduled?

Are there language examinations? When?

Are there qualifying exams for both the Master and the Ph.D.?

If yes, when are they normally given?

How many trials are allowed?

Is a class offered to prepare students for the qualifying exams?

Ask your academic advisor and key professors about their current research activities or plans:

What are they actively working on?

If the person is an experimentalist, where is the lab located and are you allowed to drop in to observe?

If a theorist, is the work analytical or computer-simulated?

If it is computer work, what codes are being used?

Are there graduate students currently doing research with them?

If yes, what are they working on?

How is their research being funded and when do the grants expire?

Do you need to pass a qualifying exam before you are allowed to do research?

If not, do they have a research project in which you could participate?

Must your work be published first before basing your thesis on it?

In addition to your thesis, how many publications are you expected to generate?

Do they feel that you are currently ready to take on advanced graduate work?

If not, what are the recommendations at this point?

Is there a Teaching Assistant requirement?

Plan Early With Your Academic Advisor

Be intellectually focused and oriented as you plan with your academic advisor. Together you decide the direction to take in pursuit of your degree program. You must focus and act assertively as you make important decisions which affect your future. To this end, some crucial areas that may seem obvious, but are important and require decisive action are:

Seek opportunities to actively participate in your department's research.

Your first research project need not become the one on which you choose to write your thesis or dissertation.

You must dedicate sufficient time within your six-year program to become proficient in research methods and practices.

Develop rigorous intellectual and technical skills and a rational and scholarly attitude.

Expand and develop skills, knowledge, and attitudes appropriate to the scientific discipline you have chosen.

Maximize your ability to be creative.

Increase your skills, aptitudes, and mental stamina as you pursue your degree program. These attributes will become real assets throughout your life and in all professional endeavors.

Keep in mind that you are preparing for technical and scientific leadership and must, therefore, strive for excellence.

Your research effort and involvement at the graduate level is far-reaching. It will bring distinction and respect to your field of endeavor and recognition to yourself. Therefore, seek every opportunity to advance yourself in conferences, research, and personal, inter-personal, cultural, and cross-cultural relations.

Work closely with your advisor to plan wisely and to ensure your personal goals and objectives are understood as you seek to achieve them through hard work and discipline.

Your preliminary academic plan should include the following:

All theoretical courses necessary to broaden your academic background.

A term-by-term schedule covering those years you and your advisor agree will be necessary to complete those courses.

An alternative schedule in the event you need to repeat a course for any reason.

A schedule to take all qualifying exams.

A survey of potential research areas.

A survey of journals to find papers, articles, etc. on subjects under consideration for research.

Note: Your selection of courses and adopted schedule should be consistent with:

level of readiness as previously discussed;

anticipated contents of exams;

overall professional objectives;

degree requirements as set by the department;

anticipated length of graduate training; and

need to be a "full-time" student at all times.

Your particular plan will be subject to regular reviews as you progress. This plan should be adjusted as needed to reflect any changes that research interests demand. Your initial schedule (beginner schedule) will serve as a guide so you can focus on useful activities.

All plans, regardless of how temporary, need to be in a written form. You will need to make sure that whatever plans or schedules you adopt have been discussed and approved between you and your advisor.

Finding/Working with Your Mentor

Your Mentor Should Be Special

If your advisor agrees to be your mentor, you may not need to find a mentor. However, you may not feel comfortable with an advisor/mentor, and prefer to have a separate mentor. The mentor should be a person with whom you can be at ease, trust, and respect. While the mentor can be of immeasurable assistance, be careful not to confuse the role with that of advisor.

Make your request for a mentor to the chairperson and/or advisor. If there is a delay or problem in finding a mentor, you may want to talk with the NPSC contact person at your school, and the NPSC Executive Director. Success as a graduate student and NPSC Fellow will depend on your ability to utilize all available resources. Do not allow small matters to grow into chaotic situations. Again—be pro-active.

Your Mentor's Role

Strive to make the mentor relationship a good one—intellectually stimulating and mutually satisfying. The mentor serves a clarifying role offering assistance in matters requiring support, reasonable advice and intellectual stimulation. Your mentor can assist in maximizing use of your advisor and reducing stress and frustration as you move forward in your programs of study. The view of the NPSC as to the appropriate role of each participant is given below:

Department/Chairperson

Assigns advisors to students

Helps students find mentors

Academic Advisor

Provides feedback to NPSC

Gives initial orientation

Reviews student's readiness

Assists in academic planning

Helps formulate research plans

Closely supervises:

- Coursework
- Research activities
- Thesis activities
- Publication activities

Promotes professional development

- Contacts with other faculty members
- Conference participation

Mentors give supplemental advice to:

Ensure initial orientation is given before first enrollment

Ensure advisor-assisted academic planning throughout training

Ensure student and advisor's relations remain steady and harmonious

Encourage student's initiatives to communicate with advisor

Facilitate overall advisor/student relations

Help student develop effective study habits

Boost student's self-confidence and ability to remain focused on goals

Help develop self-appraisal techniques

Students assume a more active role:

To personally ask the department's chairperson to assign a mentor

To submit to readiness check before first enrollment

To secure the advisor's assistance to plan academically

To work with the advisor to define his or her research and publication plans

To confer with their mentor when in doubt

To contact the NPSC office at the earliest sign of academic or other difficulty

NPSC

Interfaces with university on student issues

Monitors student progress

Disburses fellowship funding to universities

Maintains communication

Your Degree Requirements

In the previous sections, suggestions were made concerning pre-registration, registration, and early interactions with your advisor/mentor. These issues are central to your relationship with your department and will be required after you have registered. Although there are small variations from university to university, in general the following are basic to a doctoral degree program.

First, to be admitted into a degree candidacy track, you will be required to pass an entry level qualifying exam and maintain a minimum GPA set by your department.

Second, to be awarded a Ph.D. degree, you will need to pass a comprehensive examination based on graduate level courses, and do research at a level expected of a mature scientist (the results from your work should be publishable in a professional journal). Most universities require at least two such professional publications. You must also write a dissertation on the results, and defend that dissertation before a faculty committee appointed by your department and the graduate school.

You must meet the following requirements to be put on the degree candidacy track. Depending on your school, you may have to face one or more of the following under the heading of "a qualifying exam":

> A written exam based on "undergraduate courses," at the start of your first semester or quarter (qualifying exam);
>
> A written exam based on "graduate courses," at the end of your second or third year (comprehensive exam); and
>
> An oral exam based on your research project (usually after at least two years of graduate studies).

This handbook emphasizes how to increase your chances to do well on the written tests. The oral exam, based on research work, is a formality; by the time you discuss your data in a public forum, your research advisor will have given their approval to the quality of your work. Cooperation between a graduate student seeking to earn a Ph.D. and their research advisor has always been an integral part of a graduate student training program. A devoted research advisor will enhance the professional respect your work will entail.

Qualifying Exam Preparation

With adequate undergraduate preparation, the fall term's qualifying exam should not require extremely hard preparation. The following important pointers may assist your readiness for this exam.

Pointer No. 1: Practice on Old Exams

Preparation for an important examination requires study and practice. The more you practice, the easier it will be to perform. This is especially true in qualifying exams. Graduate departments usually make old exams available to incoming students so that they can know and understand the standards by which they will be measured. The aim is to give each student the chance to test intellectual skills and to overcome apparent weakness through self-evaluation. Practice on old exams and refer to your undergraduate textbooks to refresh your

understanding of previously learned theories. It is on those theories that you will be tested.

Practice on old exams not only to refresh your mastery of elementary concepts and theories, but also to experience the difference between undergraduate testing and graduate testing. Even when the tests are based on the same subject material taught at the undergraduate level, there is a real difference between undergraduate testing and graduate testing. Frequently at the undergraduate level the test giver will count heavily on the taker's ability to use known equations or formulas to solve the problems. At the graduate level problem-solving requires more creativity. The levels of understanding of basic concepts might be the same from student to student, but the ability to think creatively, using both intuition and learned analytical skills, might be very different.

You can learn to be more creative and intuitive. To succeed you must learn to do it "with pen in hand!" You improve your power to perceive, conceptualize, solve puzzling problems, and express your thoughts more effectively by writing your ideas down. There is simply no better way to improve one's thinking power than by trying it in written form.

Regardless of how trivial a problem looks, you cannot claim to know its solution until you have completely written it down. Reading old exams over without actually trying out the solutions on paper is not an effective way to prepare for an examination. Similarly merely reading appropriate chapters in a textbook that seem to explain the problem, is not an effective way to learn. The best way to verify your understanding of the ideas involved is to try the solution in a written form after you have reviewed the related theory in a textbook.

Pointer No. 2: Avoid Procrastination

The fall semester qualifying exam causes frustration for many graduate students due to its timing. Because it is given right after the registration, many students feel the best time to prepare for this exam is during the summer months. The problem: Incoming NPSC Fellows must spend the first summer fulfilling their internship with their sponsoring employer. This leaves little free time for preparation.

Despite this restriction, you can still prepare adequately if you do not procrastinate. Never wait until the last two weeks before the exam to start your preparation. After you confirm your admission and when your graduate testing will occur, ask your department to mail copies of old exams so you can get started as early as possible. As soon as you receive the package, start working a little each day. Those who start practicing on old exams early usually do better at testing time. This is one of the several intellectual knobs you can turn to take control of your personal destiny. An early start helps spread out your work load and avoids last minute cramming. Discuss your need to prepare for your qualifying exam with your mentor at your employer's site as soon as you arrive. Assistance is available.

There are two other reasons for getting started early:

First, you will give yourself plenty of time to review the solutions you have worked out, as well as the associated materials from old textbooks to refresh your memory. Remember—solutions will be of no use unless you can quickly recall them in the exam. As you try out old exams, each time you feel your solution is sound, commit that technique to memory, and review it frequently. The more time given to practice, the more you can commit things learned to memory.

Repeated reviews of your answers to problems, and textbook theories used to work out those answers, will be an excellent way to gradually raise the level of understanding concepts.

Second, an early start gives you the opportunity to strengthen your knowledge. You can cover, at your own pace, topics which some of your instructors may have skipped or skimmed through. You must be able to capably address problems on topics that may have been only briefly covered. Find time, therefore, to review those chapters if analysis of old exams indicates you will be tested on them. In studying the old exams, chances are that you will develop a feel for the areas from which test questions may be drawn.

Pointer No. 3: Practice on at Least the Last Five Years' Qualifiers

From the most recent to the oldest, start working on problems from previous exams and cover those given during the past five years. You will need to practice on roughly ten different exams. By covering that many exams you will see a trend develop: the most common topics in your discipline will be revealed as well as where problems are regularly drawn. This will help you review chapters dealing with those topics more intensively and thoroughly. Testing incoming graduate students for their levels of preparation is based on the assumption that anyone with a bachelor's degree should have a basic understanding of topics in their field. Qualifying exams are written accordingly and exam problem topics are not chosen arbitrarily. The process has elements of predictability. You will detect similarities between exam questions written over the last five years. Given enough time to prepare, you will develop a sense of expectation that you will master the exam questions.

To maximize your chances to cover all the old exams on which you will practice, make a plan! Establish a schedule that sets dates at which you reach that testing period. As you reach the midpoint of summer, make an assessment of where you are to see if you need to work harder and faster. Self-confidence is what you are building. Do not block your mental faculties by focusing on worry and anxiety. You can convince yourself that you are up to the job requirements.

Pointer No. 4: Make Summaries of the Chapters Used to Solve Problems

As soon as you have used a textbook chapter to solve a test problem, summarize the contents of that chapter in your notebook. The summary will be part of the notes you need to review in preparation for the exam. A combination of those summaries and the solutions will serve as a handy reference before the exam. Just reading a chapter is not enough to help you assimilate the principal elements of a vital theory—you will benefit from readings by summarizing what you have read. In the case of textbook summaries, the authors and the publishers have already divided chapters into topical sections. Copy only the essentials of each section—those sentences that embody definitions, theorem demonstrations, equations, and other similar concepts. Making flash cards for most-often wrong or forgotten concepts, equations, and derivations is useful for improving recall.

Pointer No. 5: Discuss Your Solutions With Other Candidates

Discuss the correctness of solutions and answers with either a group of fellow classmates, or with some other person who has a good understanding of the material. This phase in your

review plan can be done the last two weeks or so before the exam.

If you have been working alone, you will still have two weeks to interact with other degree candidates on your campus. The fall semester's qualifying exam is usually given two weeks or so after registration, which may be enough time. Traditionally students who want to cooperate with each other do so at this time by forming small discussion groups. In many cases, only two or three sessions of five hours together, comparing individual solutions, is enough to give an accurate barometer of your problem-solving expertise. If possible, make arrangements to arrive at school at least two weeks early if preliminary exams are given right away.

You must prepare to benefit from this type of group interaction. Experience shows that an explanation is easier to follow and assimilate if you discover it on your own. Your fellow test takers will "expect you to contribute" if they agree to form a review group with you.

If you feel lost as your fellow graduate students engage in discussions over the issues, you may want to seriously consider whether you are ready to be tested. If you are not sure, you should discuss the situation with your advisor, who may conclude that it is better for you to wait until the exam is given later the same academic year. This is why we recommend that every student undergo a readiness assessment by their department before enrolling. You may opt to wait an extra six months or so to take the exam, if your advisor believes that the delay will serve your best interest. You will need to think carefully before going against the advice of your advisor. Poor performance on a qualifying exam is psychologically demoralizing. If this should happen, remember that many Ph.D.s have failed such exams at least once. Look upon such an incident as a learning experience—learn about your method of preparation, the environment, stress level, etc.

Many students retake a qualifying exam a second or third time. If you fail the qualifying exam the first time you try it, prepare better the second time. A second chance is given when performance is good enough for the department to extend the privilege and not tacitly dismiss the student.

Comprehensive Exam Preparation

In this section, suggestions are made to prepare you for the qualifying exam, which is based on graduate level activities. Some departments require that students pass their comprehensive examinations prior to beginning their research. Other departments require their candidates to have done research before they are allowed to take the exam, as many of the questions asked are based on things which can be learned only from practice rather than from classroom lectures. This exam therefore requires even more creative thinking than the first. In most departments this exam is also known as a "doctoral exam" or "comprehensive exam." Whatever the name, this exercise marks the last written exam you will ever take as a student. The knowledge you will gain during this preparation is designed to stay with you throughout your career. It requires an integration of knowledge from a number of sources and topic areas.

You may find this graduate level exam more stressful than the entry level exam previously discussed because it takes a much greater effort to prepare and pass:

Problems are drawn from advanced theoretical topics and are harder than those found in graduate textbooks.

This exam may consist of a number of tests.

There may be an oral part that covers all the areas tested in the written part.

There are questions you cannot study before hand from any textbook. 'The oral part is given in front of a faculty committee.

You must do well in both the written and the oral parts in order to pass.

These are the most obvious differences that separate a doctoral exam from the entry level exam. Although the techniques used to prepare for the former are not radically different from those we suggested for the latter, there are some additional and specific things you can do to successfully meet the increased challenge posed by a doctoral examination. The following are some useful hints.

Hint No. 1: Begin Preparing the First Day

After you have been cleared by your advisor to start taking graduate level classes, collect copies of old comprehensive exams given by your department during the past five years.

Following your registration, begin to mark test questions that were drawn from the topics for which you are currently registered. For instance, if you are a physics major, you may have signed up for graduate level classes in electromagnetic theory, mechanics, and quantum mechanics. There will be problems in old exams drawn from all three subjects. Mark those problems in your binder. Do not mark problems drawn from statistical mechanics, condensed matter physics, etc.; wait until you register for those topics in a future term.

Read each old test problem you have marked, and match it to a specific chapter in the textbook your class is using for that subject. Prepare yourself to work on old test problems as the corresponding subject matter is being discussed in lectures by the professor. In the previous example you will need to do this for old test questions drawn from electromagnetic theory, mechanics, and quantum mechanics. This is a relatively straightforward thing to do, since at this point you are not trying to solve any problems. Simply write the chapter number in the margin near the corresponding test question.

Next, as your professor's lectures reach those chapters you singled out, work on assigned problems in parallel with related old test problems previously marked. This is an effective way to practice on old exams without having to set aside a specific time to refresh your memory. You will be amazed at how sharp your mind can be in attacking old test problems, using this technique.

One advantage using this approach, i.e., being deeply immersed in the subject matter of interest (via lectures, assigned problems, reference reading at the library, discussions with classmates, etc.), is that your mind will be adept at tracking solutions. The best time to practice both old and new problems about a given subject is when you are still actively studying that subject and your mind is at a high state of stimulation.

Another advantage is you will find it easier to get your professor's assistance if or when you get stuck (or your professor will direct you to the faculty member who wrote the question when the test was given).

You may ask for more sample "test problems" from your professors, especially those who are likely to author the next exam. The fact that you will be working simultaneously on old exams, while your mind is concentrating on related subject matter, will make the old exams almost look like ordinary tests. This will enhance your ability to grasp explanations given by the same people who will actually test you when the time comes. This technique will help you pace your preparation and reduce the need for cramming.

As previously suggested, save all solutions in a special notebook or binder for future review and discussion with fellow degree candidates as the date of the test approaches.

Hint No. 2: Use All Available Department Resources

As you begin to work on old tests and your homework problems, make good use of your department's library. Ask for textbook suggestions from older students and advisors. You will find books with hundreds of worked-out problems in your discipline. Most problems are as difficult as those you would find in any doctoral examination. The techniques used by the authors to solve those problems are intended to help advanced graduate students learn to reason at the level expected in their fields. Such problems can be found in:

standard textbooks (mostly of Western European origin);

"single topic" problem books (with solutions) at the graduate school level;

old collections of doctoral exams given at other institutions.

Once you have found a solution which contains the technique you are looking for, don't just read it: copy it, and begin at once to commit the newly learned technique to memory. Keep in mind that you are trying to do things at the doctoral level. This is the time for you to work harder than you ever have before. Focus on your work and work methodically to be in control. Channel your energy toward mind-strengthening activities.

Hint No. 3: Stay Intellectually Focused

Always remind yourself that you are earning a Ph.D. degree. Focus on that goal. At a lower energy level, be aware of professional goals—this will give you long term direction. After you successfully pass your comprehensive exams and near the completion of your dissertation, begin to focus more energy on your next career step.

Hint No. 4: Interact with Other Degree Candidates

It is important that sometime prior to your exam you form study groups and discuss solutions to old test problems with fellow candidates. As pointed out in entry level exams, practice will be of no use if you cannot recall problem-solving techniques during the actual exam. Study groups expand by repetition the creative techniques and problem-solving approaches of all members of the group. An effective way to commit teamed techniques and remember them is to verbalize them.

Hint No. 5: Get Advice From Graduate Students Who Have Taken the Exam

Other students can give insight as to what different professors expect and in what way they prefer problems be approached. They also may have additional hints not covered in this handbook.

Hint No. 6: Review Entry Level Exam Suggestions

Many of those suggestions are applicable when preparing for doctoral examinations.

Last Hint: Consult Faculty Members Who Prepare This Year's Test Problems

Some faculty members may let students know from which topics they will draw when they write test problems. It is particularly important to understand what professors (with whom you have not yet had formal classwork) feel you should know as a Ph.D. in your discipline. Find out what research is being done by the faculty members who are preparing questions for the exam. This is the area that they are excited about and often it is at the front of their minds when they are writing exam questions. Some graduate students call this "intelligence gathering."

Maintaining Your Minimum GPA

A grade point average below 3.0 may exclude graduate students from degree candidacy even if the qualifying exam has been passed. It is the standard benchmark by which all graduate students are measured, in addition to passing qualifying examinations. Your fellowship requires that you maintain a minimum of a 3.0 GPA, or the minimum required by your department. Many universities expect Ph.D. candidates to maintain a much higher GPA. One university referred to a 3.7 GPA as "average" and did not admit the student past the master's degree level.

Your ability to maintain an acceptable GPA will depend on two key factors: 1) your undergraduate preparation; and 2) your handling of graduate course work. The following suggestions should help you maintain a GPA above the required minimum.

Satisfactory Undergraduate Preparation

This is the most important suggestion we will make in this context. In order to ensure success, enroll in graduate classes for which you have adequate undergraduate preparation. Before you enroll, have your advisor assess your state of readiness. This crucial step will enhance your success in course work. There is evidence that, with no serious gaps in background preparation, chances for success are high. Most GPA problems experienced by graduate students can be traced to inadequate background preparation. Be aware that universities do not stress or cover the same material in course content. This is not a reflection on the student's ability, but rather on their exposure. An assessment of your readiness is an excellent way to decide if you need to take intermediate courses to fill any gaps in key areas before you try taking more advanced courses. If you find yourself sinking—call the NPSC Executive Director immediately.

Good Habits

Keep in mind that suggestions given in this section will not and cannot be useful to you if you ignore gaps in your background before enrolling for classes. When your undergraduate preparation is adequate, improving study habits is an effective way to earn good grades and maintain an acceptable GPA.

Recognize Differences in Graduate and Undergraduate Education

Good attendance is imperative. Here are some of the reasons why you should avoid skipping your classes.

Reason 1: The core-contents of your courses will probably be found in your professor's notes and lectures, not in a standard textbook. Lectures cover more subject matter than that found in textbooks. At the graduate school level textbooks are used mainly to:

give the students some idea of the level at which the course is going to be;

provide a general idea of the topics to be covered and act as a reference;

supplement the professor's own notes; and

provide homework problems in addition to what the professor prepared.

Professor's lectures at the graduate level are equal to or more important than the text. Lectures usually include problems that can be crucial to future tests and homework problems. As a way to increase the students' involvement and prepare them for future exams, graduate professors regularly leave out proofs to important theorems (not found in textbooks), making them part of uncollectable assignments that can be tested at a later date. As the course progresses, such assignments are often discussed by professors in a different context thus giving those students who never miss classes excellent opportunities to improve on their solutions.

Reason 2: Good impressions always count. A professor who has developed a good impression of you, as a student, is more likely to give you the benefit of the doubt. Your class attendance can tell a lot about you and the way you feel about yourself, your studies, your ambitions or lack of them, and your expectations. Poor attendance and a general show of laxness create an impression that you don't value the course information being given and you don't respect your professor.

Adopt Good Scholarly Habits

Punctuality. Be prompt. Nothing irritates and negatively affects a professor's attitude toward a student more than seeing that student consistently enter the classroom long after the professor has started to speak.

Good note taking. Your class notes should be as complete as possible. Test questions frequently are permutations of questions solved during a previous lecture. The information conveyed will thus show no gaps later. Sometimes students miss test questions only to later discover that the needed solution had been clearly and completely given in some previous lecture. Recording lectures is also a good idea (with advance permission).

Keep in mind that graduate school professors take seriously the notes they prepare for their lectures. Those notes represent the core of the scientific theories to which they have adhered, both through discussions with colleagues, and from their own research activities that might span several years. By agreeing to give lectures (some professors prefer not to teach), they want to pass on those theories to the next generation of researchers. That is exactly part of your graduate training: learning directly from the experts.

Hand in your homework on time. Doing your homework is a way to extend your learning activities beyond the classroom boundaries. It is an integral and vital part of your training. In a previous section we urged you to "learn to think with pen in hand" which is the basic objective of homework assignments—especially in graduate school. Homework helps you to consolidate, in your mind, what you have picked up in the lectures. By spending hours doing homework problems, you will better understand the topics covered, develop greater insight into the general subject matter, and get accustomed to thinking along the lines required of those who want to become experts in that field. This will make it easier to understand future test questions and become aware of how hypotheses can be formulated in ways that are relevant to scientific research. The result: you will become a better student, hence more capable of handling course work to maintain a good GPA.

Problem-solving assignments are pedagogical tools for teachers to keep talking to the students following the lectures, and to verify, when they meet again, that some learning has taken place. **As a matter of fact, in all physical sciences that rely**

on mathematics, experience shows that no serious learning is taking place if the student shows no ability to solve problems specific to the subject matter being studied. To your professors, an ability to solve problems is a testimony to your understanding of the subject being discussed in the lectures. It is an important feedback for you and them to gauge how well you have assimilated the subject matter.

How to Improve Your Test Scores

The following list includes basics you can do to better your test scores:

Do not procrastinate! Start doing your homework the same day it is given.

Learn to match problems with newly covered theories and equations.

Use the library to learn additional new problem solving techniques. Use the library early, especially if you have to use reference books from a syllabus.

Try problems before discussion section (if there is one). Be prepared to ask questions.

Use your contacts to see if a senior graduate student might occasionally provide additional insights and assistance.

Take the initiative to form a study group.

Commit corrected problem-solving techniques to memory.

Use the Internet.

As a part of your scholarly habit-forming strategy, there are other things you could do to improve your test scores and maintain a good GPA. Again, suggestions in this section can be useful to you only if undergraduate background gaps have been successfully addressed. Much of the information we included in conjunction with preparing for the qualifying exams can be used and applied to regular classroom examinations. Here are some reminders:

Reminder No. 1: Start studying before a test is announced.

The most common mistake made, even by advanced students, is waiting for a professor to make an announcement before preparing for an exam. This frequently results in cramming, poor retention and recollection of the subject matter, nervous behavior at test time, performance below real potential, etc. Do not fall into that trap. The first day you begin attending lectures should also be the day you begin to study for your exams.

Reminder No. 2: The ideal time to review all class notes is just before going to sleep.

Cybernetic studies indicate that the human brain registers information received just before sleep better than any other time. The brain can go over and process this information more thoroughly for you again during sleep. You want to develop attitudes and practices that enhance your ability to remember! Spread your review activities out by getting started early and doing a little bit every day.

Such a strategy will enable you to:

follow the major topics on which lectures are being built;

follow the major theorems and equations on which those topics rest;

reproduce theorem demonstrations later without your notes; and

correlate newly studied topics with previously covered materials.

Some Last Words

Use the last day before the test to refresh your memory.

Many people have improved their concentration through Yoga-like exercises. You may want to do some reading on this technique. Try to relax!

Get a good night's sleep the night before the test (at least a good six hours of deep sleep).

Five minutes of meditation never hurt.

Eat a light breakfast an hour or more before the test.

Find Your Research Project

Perhaps no other activity in graduate school will give you a greater feeling of personal achievement than successful completion of your doctoral research project. Indeed, upon successful completion, this research is the one activity which will define you as a professional scientist and bring you recognition, respect, and prestige by:

qualifying you to earn a Ph.D. in a physical science;

transforming you into an authority in a complex scientific field;

publishing your ideas and name in important professional journals;

ensuring you a forum in professional gatherings;

opening the door for you to high-paying professional positions in education, government, etc.;

providing the springboard to becoming a leader in research.

Before these things can happen, you must decide on a research topic, draw an experimental plan, implement that plan, collect serious data, interpret the data, and show the results to a knowledgeable public through seminars, conference presentations, etc.

The initial phase happens to be the one with which many new graduate students sometimes have problems deciding on a research topic. This is particularly true if a prospective thesis advisor does not offer options based on the advisor's ongoing projects. In that case you will most likely need to actively work with your advisor to define a project for yourself.

In this chapter we examine some ideas you might want to consider while you are still trying to decide on your research topic. Furthermore, since during our survey it became obvious that some Fellows do not seem to realize how important it is for them to get published, we will also discuss this aspect of your graduate training.

Suggestions in this chapter are in the context of a doctoral research project. As was suggested in Chapter 1, you can participate in other projects, even if they are not going to be part of your thesis, as long as the opportunity to participate exists. Such activities will speak well in your favor when prospective employers read your resume.

Pure Science or Applied Science?

Before selecting your project topic you must decide: Do you want to be a pure scientist or an applied scientist? The more you identify your project as something that is closely related to your vocation as a scientist, the more focused you will be mentally and intellectually while carrying out the investigation. Strong identification with your project will keep your motivation high, a necessity for your work, because scientific research demands dedication and sometimes sacrifice in terms of other activities of personal interest to you.

Pure science simply means science for its own sake even if nothing materially useful might emerge from the investigation. The objective of pure science is truth for its own sake—to satisfy the innate curiosity that drives us to try to understand

why and how everything around us works. Many scientific discoveries made in the course of doing pure science have been transformed into practical applications. Those transformations usually result from engineering work that follows a discovery made by a pure scientist.

The main objective of applied science is to use science to help solve practical problems. Before an investigation is launched, its usefulness in terms of practical applications must first be established. This necessarily restricts the choice of topics contemplated for investigation, since each topic must first be judged to be of practical interest both to the investigator and to the people who give financial support to their activities. However, this division of science into pure and applied branches is not really as strict as it sounds. In almost all branches of science, from physics to biology, many contributions to pure science have been made by those who supposedly were working as applied scientists. Indeed, there are many scientists who do pure science after they complete their graduate training even though their doctoral thesis was based on applied research, and vice versa.

As you contemplate the kind of research you want to do, allow yourself to be flexible as a graduate student. You learned in Chapter 1 that what you end up doing for the rest of your life may have very little in common with the topic of your doctoral research. Keep an open mind. What is very important to you at this point is the general training as a scientist, albeit in a well-defined discipline. You need to develop professional and universally useful skills that will be keys to your professional success, regardless of the particular specialty where those skills will be applied. While it will be good to identify your project as something that matches your future aspirations as a professional scientist, use some flexibility in assessing your options.

Theoretical or Experimental?

By now you should know if you like theory better than experimentation. Whichever attracts you most, it is also a good idea to ask yourself some fundamental questions before you make your decision. Take a realistic look at your undergraduate records to make sure they are consistent with your aspirations. For instance, if you want to go into theory, ask yourself whether mathematical rigor has been your strongest point to date. Did your performance at exam times demonstrate that rigor? It is particularly important to realize that, even if your undergraduate grades in your discipline are quite good, it may still be risky to choose theory if your grades in mathematics have been rather marginally satisfactory. Theoretical research is quite abstract and mathematically difficult. It is also easier to find a research group and a job after graduation as an experimentalist than as a theorist. This is a fact of life to keep in mind.

You may, however, find you don't like experimentation if (as an undergraduate student) you felt particularly uncomfortable doing lab work. Serious weakness in laboratory techniques can be camouflaged at the undergraduate level. This is possible because many lab assignments are done within a group framework where assertive individuals end up playing greater roles than others, causing the latter to essentially ride along.

Define Your Research Topic

Whether you choose pure or applied science, theory or experimentation, there is no unique approach to finding a

research topic. Much depends on academic background, on who your academic advisor is going to be, on your particular discipline, and on the resources that might be available for you to carry out the research. Regardless of how the topic is chosen, make sure that once your choice has been made, you have at least an interested faculty member (if not your advisor or mentor) who will support your efforts from start to finish.

Whether you go into applied or pure science, the following are some of the resources you may want to tap during your quest for a research topic:

Your academic advisor's proposals

Many graduate school admissions are effected only after some faculty member has identified the applicant as someone they would like to have on board to work on their research project. If you fall into this category, finding a research topic will not be difficult. All you need do is to work with your advisor to develop a research plan that meets your doctoral needs.

Your sponsoring employer's proposals

It may happen that in the course of your internship with the sponsoring employer, you develop a strong interest in your summer project and want to transform it into a long-range doctoral research activity. In that case you need to first gauge your summer technical advisor's or mentor's opinion about that possibility. If they agree to become your thesis advisor, they will need to consult with your official advisor back on campus because:

1. Your university must agree that such an arrangement is feasible.

2. An off-campus advisor and your departmental advisor must work together to schedule the timing of your exams, seminars, conference presentations, and journal article publications in such a way that your best interests as a doctoral candidate are served.

3. An off-campus advisor will need to work with your departmental advisor to set up a thesis committee for you at the appropriate time, etc. The off-campus advisor also serves on this committee.

Should you desire to do off-campus research, you must inform the NPSC office of your intentions.

Doing it on your own

In the absence of suggestions from your academic advisor or research opportunities with your sponsoring employer, you will have to work harder to define your thesis research project. The following are some things you may want to explore if you find yourself in this situation. Remember that we only make suggestions in general terms. You will be in a better position to transform these suggestions into something practical, given the local conditions at your university.

Explore the possibility of doing research with a faculty member on a different campus or nearby national laboratory, provided that your department approves. This is not an uncommon practice. If events make it impossible for you to complete your research at your university—then follow your research. Find the professor who is on the leading edge of your research, and see if you can pursue your research topic with this professor's team.

Develop thesis research ideas that can be implemented where you will be. Use all the resources available locally to define your experimental plans. Your departmental library can provide vital information on dozens of topics that might interest you, including past and ongoing research activities by experts in your field. To get a better idea of what is going on in the department, go to poster sessions, seminars, etc., talk to other graduate students, wander around and visit labs, and browse departmental reprint shelves.

The most essential thing to keep in mind is: only start working on a research topic after you have learned enough about what others might have already done in that area. Don't spend months or years working on what you believe is an unresearched project, only to discover that someone had already thoroughly investigated the same topic and published those results in a professional journal. Your initial step should be to use your departmental library to shore up your background information. Your library contains hundreds of articles and references through which you can browse to learn as much as you can about what has been done by others regarding the particular research topic in which you will be interested. Also, draw from your research advisor's knowledge and library of relevant material. References[1] are in the form of:

Literature guides

Handbooks

Books

Review journals and review articles in journals

Abstract and indexing journals

Internet key search

A good background search at your department's library should be an integral part of your research project preparation. Again, begin by reading general information regarding the subject matter found in encyclopedias, books, handbooks, etc. Next, read specific selected review articles in professional journals including the most recently published articles. The more articles you read, the easier it will be for you to narrow down your list of journal issues relevant to your project. Take good notes as you work, including journal names, dates, authors' names, references in the articles, etc. When completed, you will be amazed at what you've learned about the topic that interests you.

Once you have done sufficient reading on your own, consult with those faculty members you believe might be knowledgeable on that topic. Such contacts will be necessary even if you already have an academic advisor, because the latter may not be an expert in the specific area of your discipline in which you are interested. It could turn out that you will ultimately be working with another faculty member.

After you have identified a faculty member who is interested in supervising your research, enlist their help in drawing up an

[1] An expanded list of specific examples is given by E. Bright Wilson, Jr. in An Introduction to Scientific Research, Dover Publications, Inc., New York. We recommend that you read this informative book as part of your preparation.

experimental plan.[2] At this point, your academic advisor becomes your real intellectual mentor. As shown in Chapter 1, many of the professional attitudes and research practices you develop while doing research will be a reflection of who will be your research/thesis advisor. Close interaction on a daily basis will be almost a necessity until the experimental set-up is routinely producing the type of quality data a doctoral student is expected to produce.

Before starting a research project ask:

1. Will it hold my interest for four years?

2. Is there going to be too much tedious work to deal with or is it varied, interesting and challenging?

3. Is there an open channel for getting assistance: a post doc or senior graduate student, for instance, who can pass down their wisdom?

4. How much will you be working on your own, and how much with others in a team or as a subordinate?

5. Will the project give you broad-enough training to make you marketable?

6. If you will work as part of a group on this project, will you have sufficient input time to learn enough about the whole project and not just your portion?

7. If part of an established project, will you have an opportunity to participate in or at least learn about project development? (If you want to lead your own research someday, you need to learn how to start from zero.)

8. How will this lead to a job? Will you be developing good contacts?

9. Are you comfortable with the theory behind the experiment? There are no right answers to these questions, but make sure you are comfortable with the answers.

10. How much "brain" work is involved?

11. Is the time scale reasonable for graduation? Does it depend on factors which could slip and leave you stranded?

You also need to ask yourself these questions about your advisor and group.

Technical Skills for Self Reliance

Working closely with your advisor does not mean you have to depend entirely on that advisor to make progress in your project. At this time, your research advisor would like you to show the ability and willingness to take initiatives, to take charge, to plan and act independently, asking for their assistance only when necessary. In fact, the more advanced you become in your standing as a doctoral student, the more inclined your advisor will be to treat you as a colleague and value your technical judgment. It is important to have a good

[2] Again, for your information, a reading of the references given above can assist you in getting organized and started.

technical foundation on which to build. This should include strong laboratory skills, well grounded ethical and philosophical attitudes, a strong mathematical background, a strong sense of self confidence, and a willingness to try new ways of doing things.

In this section we make some suggestions regarding what you can do to polish up your technical background, improve your thinking skills, and become less dependent on your advisor's assistance when you need to act on your own ideas.

Improve Your Technical Skills

As an experimentalist, one of the things your academic advisor will expect you to do on your own is the routine setup and operation of standard laboratory equipment used in many undergraduate laboratories: like oscilloscopes, vacuum systems, basic signal recording, processing devices, etc. Your advisor will also expect you to have a good background in data analysis and interpretation. On the other hand, if you are theoretically inclined, you will be expected to have a strong background in computer techniques. A good grounding in these areas makes a good technical foundation for you to build on. If you did not have the opportunity to pick up such skills as an undergraduate student, you are definitely at a disadvantage relative to those of your peers who did. Inform your advisor of the problem both during their assessment of your background preparation and during your first academic planning session.

Courses in "scientific instrumentation" are offered at many schools at the advanced undergraduate level. New graduate students anxious to sharpen their technical skills usually take advantage of such courses the first time they enroll—even with extensive undergraduate laboratory experience. A course of that kind need not be offered by the interested student's own department; many such courses are set up to fulfill the needs of students with all kinds of backgrounds. If any department at your new university offers a course in scientific instrumentation, under any name, we strongly urge you to take it the very first time you enroll. That will be an excellent opportunity for you to beef up your laboratory skills before you start doing serious research entirely on your own. We urge you to take it even if you had similar training, as course content can vary from school to school. You are older and intellectually more mature, as well as more motivated, which should help you assimilate the subject matter much better. If your school does not have a course which is explicitly geared for scientific instrumentation training, ask your advisor to help you enroll in whatever course will most likely polish up your laboratory skills. You may also wish to take advantage of short training sessions on new equipment frequently offered by your employer sponsor.

Laboratory safety courses are of utmost importance. Knowledge of sound and safe laboratory practices could save your life. Most universities offer either safety courses or seminars.

Experimental research graduate students should be familiar with laboratory practices. With a good solid laboratory background, it is relatively easy to conceive a realistic experimental project. If you do not have strong technical skills, you may strengthen these skills in a one-semester course. Strong technical skills enable you to be more independent and assertive in defining and launching a doctoral research project.

Specialized courses in computer techniques may be available for students in mathematically dependent specialties. For

instance, there are introductory and advanced courses in numerical methods using the most current computer programming languages (C++, etc.) There are also courses in computer simulations using specialized codes applicable to various disciplines. If your work requires such techniques, you may want to enroll in these courses early in your graduate studies before doing serious research.

When doing your research, maintain a professional demeanor in your laboratory. Be present during the time your professor is in the laboratory. Professor-student dialogue is of great value. If you are seen working, the perception is you are diligently pursuing your research. If you work only late hours, or hours when your professor is away, the perception is you are not working as hard as you should (although you could be putting in twice the work hours). If this is your "independence badge," be aware there may be a cost for your independence.

Impose Order and Discipline

In addition to purely technical skills, there are also basic intellectual attitudes and habits that can help you function as an effective and relatively independent scientist. Consistency and repetition will transform such attitudes and practices into routine habits so your whole approach to scientific research is automatically guided by them.

It is very important to impose control on your thinking, verbal and written communications, and all scholarly activities in order to become intellectually functional. Scientific work is a highly rational activity that relies heavily on logic. You cannot function well in this branch of knowledge unless your mind is logically organized. If your school's philosophy department offers a course in formal logic, and you have never studied logic before, now is the time to do so. In some continental European school systems, all prospective science majors are required to take a course in logic even before they finish high school. A good course in logic includes a whole chapter on "scientific methods." If your school does not offer such a course, do yourself a favor: buy a book on the subject and read it as a recreational activity—the exercise can pay good dividends in terms of reasoning and organizational skills. Proficiency in rational thinking will enhance your ability to remain intellectually on target throughout your research project, and strengthen your aptitude at problem solving—a real plus in the handling of course work and test questions. The ability to see logical links between theories and problems is necessary for graduate students to do well, in addition to their innate intelligence.

Being orderly means conceiving and planning with precision and clarity.

That is one of the reasons you need to do a thorough background investigation of any topic you want to pursue for your doctoral project. That preliminary step will help you see things more clearly and precisely. Neither your advisor nor any other faculty member will be interested in your project if it appears that it was conceived in a confused and disorderly fashion. By reading reports on what others have done, you will educate yourself on the ways valid scientific work is done from conception to the publication phases.

Being orderly means being methodical and systematic.

According to French philosopher Rene Descartes, "Method consists in ordering and arranging things toward which one must turn one's spiritual forces to discover some truth." To be

able to learn and discover new things and concepts, one must learn to impose a certain order on one's ways of conceiving and doing things. As previously stated, the best way to make improvements on your ability to think systematically and methodically is to do it "with pen in hand" by using a good word processor. Trying to conceive and plan things in your mind exclusively is no different from day dreaming. If you really want to have a project worth the name and the consideration of your advisor, do it in writing even if you have to do it repeatedly before you have an acceptable version to discuss.

Being orderly means being analytical.

Display an ability to break a complex task into smaller and, hence, simpler tasks, or a complex idea into smaller and simpler ones. More clarity, order, and precision are therefore brought into the planning and the execution phases of your research project. As you work to define your research project, never settle for general statements. Say it in detail, and write it explicitly so the meaning and soundness of your thoughts and the logical linking of your ideas can directly reflect how they would be perceived by an external audience.

Being analytical also means displaying an ability to reflect on the means contemplated to reach one's goal or to realize one's project. You will need to establish not only a sound experimental plan, but also define in detail (with your advisor's help) the desired instrumentation, the space needed to set up the apparatus, a tentative schedule for testing the set up, some estimate of how long it will take to complete the project, etc.

Finally, being orderly also means an ability to put a good story together.

During your experimental planning, it is important to explicitly state what you are trying to do before you attempt to explain it to others. Present your case so your objective appears "to make a general contribution to your field," rather than to investigate something just because it interests you personally. One of the main characteristics of science is its universality. Your topic should be general enough to interest the scientific community in your discipline worldwide. When possible, your aim should be to address some issue which is relevant to the world of science at large. More specifically your problem formulation should answer the following:

What motivated you to choose your topic?

Some previous but inconclusive work by others?

Some old or new hypothesis that remains untested?

Some long-standing known natural phenomenon that needs explanation?

A desire to settle some contradiction between two major theories?

A desire to settle some conflict between theories and earlier experiments?

A desire to theoretically explain new experimental findings?

A desire to develop a new material for industrial applications?

When you do background library research, as previously suggested, you will find it relatively easy to formulate your

project along the answer to any one of these or similar questions. The potential of your proposal to generate universal interest among experts in your field is what will likely secure your advisor's support. The above suggestions may not have covered all you need to consider while selecting your doctoral research topic, but will help get your concept started.

Why Publish?

In our survey, it became apparent that some NPSC Fellows took a casual attitude when asked about their publication status. Indeed we found students in their third or fourth year of graduate studies with no publishing plans whatsoever. It appears that many students do not realize it is vital for them, as doctoral candidates, to publish before they earn their degrees. This attitude could reflect the fact that getting published is not a standard degree requirement at many schools. Frequently, however, the requirement to publish at least two scholarly papers prior to graduation is one of those unwritten rules. Also, if the academic advisor is not particularly informative or aggressive in this respect, some students will not see cause for concern. There are very good reasons for you to publish while you are still in graduate school. Here are three of them.

Publishing adds weight to your thesis dissertation. It is much easier to write a thesis based on research work that has already been accepted for publication in a professional journal. Furthermore, your thesis will greatly impress members of your doctoral committee, as they realize they are looking at high quality work already reviewed by impartial international referees in order to be accepted for publication. Your committee members are the people you expect to recommend you in your search for postdoctoral employment. The more impressed they become with your work, the better their recommendations. Publishing also disseminates results and serves to expand the information base for the field. It allows others to build on your results, without wasting time "reinventing the wheel."

Publishing improves your chances for employment after graduation. Your sponsoring NPSC employer is interested in your ultimate employment with them. However, it is important to realize that the job market will always be competitive. People with doctoral degrees are expensive. Since the economy is always in flux, the supply of employment positions may be scarce when you graduate. All new Ph.D.'s are not automatically absorbed. Prospective employers are more selective when they hire new people. They are interested in employees who show real signs of creativity; a publication list in your resume speaks well of you as a creative person. This is why we urge you to participate in as many research projects as you can, even if you are not the principal investigator. Similarly, if you start your own project early enough, the resulting data output might be such that you and your advisor will be able to publish at least two papers based on the same general topic. Getting your name in two or more papers, while still in graduate school, can do wonders for your resume.

Regardless of your ultimate employment, publishing is a permanent requirement for you to survive as a professional. As the old saying goes: "Publish or perish!" Getting published has always been the way for college professors to advance professionally and obtain tenure.

When organizations hire people with Ph.D.'s, they want them to do creative work and play leading roles in pure or applied research. Publishing your results in professional journals is a sure sign of your productivity. Once hired, keep yourself

visible and competitive by publishing what you have done. Written reports in the form of articles in respectable professional journals can ensure you the type of recognition necessary for you to survive and prosper financially. It is one aspect of "productivity." Establishing liaisons with the publishing world should become an integral part of your graduate training. Getting published is a way of life for you as long as you earn your living as a professional scientist.

Here are some final hints to improve your prospects:

> Get started early in your research project to develop data output capable of generating at least two journal articles.
>
> Join other projects whenever opportunities arise.
>
> Develop intellectual bonds with faculty members.
>
> Develop friendly ties with your fellow graduate students whose experimental setups are adjacent to yours; contributions you make will be acknowledged when their work is published.

We all create our own sphere of existence by what we choose to observe and act on and what we choose to ignore. Recognition in science is not automatic. There are scientists in organizations who remain anonymous, obscure, and unrecognized. Be assertive. Go after your professional goals aggressively. Make your presence felt the very first semester you enroll. Let your inner confidence, your self-respect, and positive thinking radiate on those who live, work, and study around you. People respect those who are centered and believe in themselves. Release your intellectual energy, so it can be channeled into ideas and activities that promote your advancement and success.

Pointers on Forming a Thesis Committee

Before closing this chapter, we will discuss your need to form a thesis committee. After you have fulfilled most of your degree requirements—including course work, and qualifying and comprehensive exams—and written your dissertation based on your research project, you need to defend that dissertation before a faculty committee. The session is called a thesis defense. This will be your last hurdle before you are granted your doctoral degree.

Putting a thesis committee together is not difficult if you have been cultivating intellectual ties with faculty members. A thesis committee comprises at least five faculty members, one of which will serve as the committee chairman. In most schools your academic advisor may not become your thesis committee chairman, but automatically becomes an influential committee member. In most schools, half of the committee's members are chosen by you, the other half by the committee chairperson. You will have the right to object to the appointment of any faculty member you do not wish to have on your thesis committee. All the deliberations associated with member selection are "low key" and confidential. Normally, many students first consult with their own advisors regarding the composition of the committee. Sometimes the advisors will permit you to choose freely if you have established good relations with those you want to approach. Some cues in forming a defense committee:

> Make sure all potential members generally get along well with your advisor.

Make sure members also get along with each other, including the committee chairman.

Be certain the chairman is an influential faculty member and has generally viewed your academic and research preparation favorably.

Make sure no potential member is approaching retirement.

Make sure members have a track record of graduating students with reasonable dispatch.

Have private consultations with those members you want to personally select, making sure they indicate they honestly believe it is time for you to complete your academic training.

Finally make sure members are given enough time to read your thesis, to appreciate what you did before they meet.

NPSC and You

When Should You Contact the NPSC Staff or Sponsoring Employer?

It will be your responsibility to communicate with both the NPSC staff and your sponsoring employer whenever there is a new development in your training that requires some immediate action, or which might ultimately have a significant impact on your training. With prompt communication, any problem can be successfully managed. Otherwise, small problems can develop into major ones. For your self-interest, you are expected to be the first to contact NPSC as soon as you find yourself with a difficulty that could disrupt your education. Listed below are the kinds of issues about which NPSC needs to hear from you (some are positive!). At the end of each semester, please mail a copy of your transcript to the NPSC Los Angeles office.

Issue

Change of name, address, telephone, e-mail address

You have problems being assigned a advisor or mentor

Employer problems

You have difficulty with a stipend payment

You did not receive an academic evaluation

You were not given an initial orientation

You want to change majors

You have problems with your workload

You have problems passing the qualifying exam

You have problems passing the comprehensive exam

Your GPA has fallen below 3.0

You want to change schools

You wish to postpone a summer internship

You have questions about your stipend

You have questions regarding the internship

You plan on graduating next semester

You receive an award, get married, etc.

Writing or posting your resume

You plan on graduating next semester

NPSC Policies and Procedures

National Physical Science Consortium Policy on Teaching Assistantships

The NPSC recognizes that time spent as a teaching assistant has academic merit and will enhance a student's ability to reason and communicate. The Consortium also recognizes that teaching may be a degree requirement of some academic departments attended by NPSC Fellows. The NPSC endorses such requirements. The NPSC wishes to make certain that all NPSC fellows have sufficient time for their studies and research in preparation for examinations and other academic requirements. The NPSC sets forth this policy in the belief that the majority of graduate students' time should be spent on academic activities that directly support the successful completion of their graduate studies.

Policy

During the first two (2) years of an NPSC fellowship, it is strongly recommended that teaching assistantships be limited to one-quarter time for the academic year (0.25 FTE).

During years three (3) through six (6) of an NPSC fellowship, teaching assistantships should be limited to a maximum of two additional terms (i.e., one academic year) at one-half time (0.50 FTE).

The National Physical Science Consortium reserves the right to reduce the amount of stipend paid to any fellow who exceeds the recommended guidelines as set forth in the NPSC Stipend Supplement Policy. Any such reduction shall be based on the pro-rata amount of the NPSC stipend minus the income derived from the teaching assistantship time that exceeds this policy limit.

All requests for waivers from this policy must be in writing and directed to the NPSC Executive Director. Decisions of the Executive Director are final.

National Physical Science Consortium Policy on Research Assistantships

The National Physical Science Consortium recognizes that time spent as a research assistant has academic merit and will enhance a student's research ability and broaden their research background and may lead to the clarification of their dissertation topic. The NPSC endorses such research.

The NPSC wishes to make certain that all NPSC fellows have sufficient time for their studies and research in preparation for examinations and other academic requirements. The NPSC sets forth this policy in the belief that the majority of a graduate student's time should be spent on academic activities that directly support the successful completion of their graduate studies.

Policy

During the first two years of an NPSC fellowship, it is strongly recommended that research assistantships be limited to summer only.

All requests for waivers from this policy must be in writing and directed to the NPSC Executive Director. Decisions of the Executive Director are final.

During years three through six of an NPSC fellowship, research assistantships may be accepted by students for the summer months. Additional research assistantships for the academic terms must be reported to the Executive Director.

The National Physical Science Consortium reserves the right to reduce the amount of stipend paid to any fellow who exceeds the recommended guidelines as set forth in the NPSC Stipend Supplement Policy. Any such reduction shall be based on the pro-rata amount of the NPSC stipend minus the income derived from the research assistantship time that exceeds this policy limits.

National Physical Science Consortium Publication Acknowledgments Policy

Since it is common practice to acknowledge all forms of financial support which facilitated completion of a research project, the National Physical Science Consortium requires formal recognition by NPSC Fellows on publications which they either author or co-author.

The following or similar statements should be used:

"This research was facilitated in part by a National Physical Science Consortium Fellowship and by stipend support from (indicate employer sponsor and employer mentor/supervisor names here)."

"This research was sustained in part by fellowship support from the National Physical Science Consortium and (indicate employer sponsor and employer mentor/supervisor names here)."

"This research was greatly facilitated by stipend support from the National Physical Science Consortium. Opportunities to engage in and complete the research reported in this article were provided by (indicate employer sponsor and employer mentor/supervisor names here)."

National Physical Science Consortium Stipend Supplement Policy

NPSC Fellowships provide an annual stipend to Fellows attending graduate school and progressing toward their graduate degree. At the time this document is being prepared, active NPSC Fellows receive $12,500 during the first four years of their fellowship and $15,000 for the remaining two years. However, the NPSC intends to review the amount of the fellowships annually. A significant increase is planned for the 2003-2004 academic year.

NPSC policies permit fellows to work during the semester as either a Teaching Assistant or a Research Assistant. The maximum time permitted as a TA or RA is specified in the TA and RA policies above.

Some universities may provide additional funds to NPSC Fellows in the form of increased stipends. This can occur when the amount the university provides to their Research Assistants is higher than the NPSC stipend.

NPSC feels that the current stipend provided through the NPSC Fellowship is adequate. This should allow the Fellow the freedom to pursue her or his studies and research without the need to seek additional income through employment from within or outside the university beyond the NPSC RA/TA policies.

Stipend Supplement Policy

Any active NPSC Fellow receiving supplemental income through employment or other non-personal sources, during the school year, is required to report this fact to NPSC.

Should the total of any supplemental income exceed the current NPSC Fellow's stipend or the amount of the university RA (whichever is greater) by $5,000, NPSC will deduct the amount over $5,000 from the NPSC Fellow's stipend.

Waiver

All requests for modification, adjustment, or waiver of this policy must be made in writing and may only be granted by the Executive Director.

Have a successful and Exciting School Year!