

To: All Current and Future Ph.D. Students

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Subject: Requirements for a Ph.D.

The motivation for this description is to take the mystery (if there is any for you) out of what must be done to obtain a Ph.D. These guidelines are not just for students at Cincinnati, but apply roughly to students everywhere. Do not let these guidelines and expectations overwhelm you, because they are spread out over several years. Also, a lot or all of this may be old to you, so the rest of this may sound like preaching. However, by reading this we will all be in the same framework without any confusion about expectations.

SKILLS AND REQUIREMENTS FOR A Ph.D.

Creativity

Your dissertation should be yours and not your advisor's. The majority of suggestions by your advisor will be wrong or lead nowhere. It is your job to take them, modify them, develop variations on them, check them, etc. and come up with something that works. Thus, a major component of a Ph.D., is the creation of new techniques, approaches, chemistries, routes, theories, models, materials, etc. This component of creativity must be distinguished from work for an M.S. which usually involves being given an idea and obtaining and analyzing data.

Aggressive Attitude

Make it work! Nothing works by itself.

Attention to Detail

Details are what make or break engineering and science. Lack of attention to details makes people think you are sloppy which in turn makes them doubt the value of your work.

Productivity

Productivity is measured by the number of completed pieces of original work which can be presented to the community. A paper is an accepted criterion. Thus, a key measure of productivity used by virtually everyone (employers, colleagues, reviewers) is the total number of publications (5 - 10 or More from your Ph.D. is good) and presentations.

Giving and Taking Criticism

You should actively seek out criticism of your work from every source possible. Criticism is a resource. Everyone must be able to take and give constructive criticism without taking it personally. You are in trouble if you are not able to handle criticism, because the rest of

your life in science and engineering will be full of it. You will also find yourself having to criticize other peoples' work and do it without attacking them personally. Do not confuse your self-worth with criticism of your work; they are totally unrelated.

Organization

A key to success is to be organized. Your lab notebook should be up to date and be the only place you write all of your results, thoughts, observations, calculations, etc. Only data from your lab notebook that can be repeated from the description in your notebook can be used for your papers and thesis. Add comments to computer programs, because you or somebody else will be using them in the future. Make a list of all data-files and document files on floppy-discs, so you can look them up quickly at any time.

Being Informed

Read papers in areas outside of your project, or you will have only a narrow perspective.

Working With other People

Introduce yourself to the people at work, so they know who you are and what to expect from you. Realize that everyone is busy and plan ahead. Do not expect them to fulfill your requests right away. **If you think the people you are surrounded by are hard to work with, just wait.** Also, you should always ask yourself how much of your problem with the other person is really your fault.

Depth and Breadth of Knowledge

A Ph.D. must become an expert in her or his area. The person must know more than their advisor or anyone else about their research, even if it is narrowly defined. This requires going to the library religiously, reading papers and books, getting criticism, talking with other people, etc. It requires knowing the basics and limitations of any theory behind what you are doing or the experimental data behind your theory. It also requires knowing how what you are doing fits into the bigger scheme of things so that you don't over- or under-estimate its importance. Going to the library once every week is not too often.

COMMUNICATION SKILLS

Writing

A student must be able to communicate ideas effectively on paper in a variety of forms and be able to recognize when to use certain styles. For example, a report to a manager at a company may be very brief without details, while a full paper in a journal may go into excruciating detail.

Your first experience may be preparing a draft of a paper after outlining it with your advisor. This is often frustrating for even the best writers because you have to develop a feeling for what type of and how much information belongs in a paper. This happens to everyone and is

not something to worry about. A certain level of detail and an accepted formula are required which can only be learned by writing papers and reading other people's papers.

Do not wait to write until all work has been long done. You'll find out that you missed something important. Writing down the work in a paper form for a journal will help you to discover all the details that make the difference!

Oral Communication

Presentations are very useful because they provide you with feedback about how to present your work - both orally or on paper - in an ever improving fashion. Furthermore, giving presentations helps you define and redefine your research project over and over again.

You must be able to give effective presentations to different types of people, conference attendees, job interviewers, your colleagues, etc. This requires understanding how they think and what they value. Who is your audience, Chem. Engs., Materials, Chemists, non-science people, a mixture, etc.? A good way of practicing is by giving talks in our group meetings, over lunch with your friends, to a group of other students to a visitor of our laboratory etc. PRACTICE, PRACTICE, PRACTICE.

Visibility

Your visibility will largely determine your fate after you graduate. The more people who have seen you and your work, the better are your chances of getting to where you want to go. Visibility means preparing and presenting posters, giving talks, writing papers, being mentioned by someone at a meeting or elsewhere in a favorable manner, speaking with visiting sponsors, calling people up to discuss problems, etc. All of these add up to the overall impression people will have of you and your work.

BAG OF TRICKS

Every person going through a Ph.D. program, while realizing it or not, is developing a bag-of-tricks that they will carry with them for a long time. This bag is your collection of skills in materials characterization, computations, synthesis, process creation and design, etc. Choose the ones that you enjoy the most and collaborate with someone else to obtain the others.

Typical Road Map For a Ph.D

A typical (note that there will be large deviations from this description depending on the particular case) sequence of events and expectations for a Ph. D. student is as follows. The overall time is roughly 4 - 5 years after a B.S. provided that you study in the same field. (Three years is not common and only occurs for people who stay-at a single university on a single project, do not switch majors, and have done high-quality research as undergraduates) The first three quarters are spent primarily on classes and learning the background for your field which usually involves a lot of reading and library time (searches, books, background from classes), and a limited number of experiments. The first summer is the time where you are expected to work more than full-time to get more of the library work and experiments done on your project. The

second school year involves finishing (in some cases) your classes and continuing the experiments and reading. The second summer involves heavy research (experiments, calculations, etc.) along with reading for your project. The third school year involves a few more classes, but less time is spent on classes because there are fewer of them and more time is spent on research. Also, these classes are usually chosen to help you with your research. Beginning the third summer is when the serious and intensive work begins until you have graduated.

This intensive work continues until the student has reached the level of being completely independent from her or his advisor. Independence has several dimensions including identifying interesting areas to work in, thinking of ideas in this area, formulating a plan and objectives, doing the calculations or experiments, critically evaluating the results and improving on them, writing papers to communicate the results, presenting the results orally, critically reviewing papers, interacting with people in the same area, and others. Remember that independence is a key requirement that is required for graduation and must be demonstrated before graduating.

It is important to mention here that the above steps occur gradually and not all at once in a blinding flash. The final product will be determined not by the time spent at the university or the sheer amount of energy expended, but will be determined by your effectiveness and the integral over time of the amount of time spent multiplied by your effectiveness.

Don't get stuck and stay stuck. If you are confused about what to do, talk to someone, your advisor, other professors, friends, postdoctoral fellows, students, company representatives, etc. If you stay stuck you'll get depressed which leads nowhere.

Another important thing to note is that the above sequence is almost never followed exactly because of myriad factors. Everyone goes through highs and lows, periods of high productivity and low productivity, happiness and unhappiness, etc. This is the norm and the integral is what counts.

Enjoying what you do

Keeping in mind the number of years you spend in school and the even larger number of years you may spend working in your area, you must enjoy your work. This does not mean that you must enjoy everything you do, but that you enjoy enough of it to be happy overall. ***If you cannot answer yes to this question, you must ask yourself what you are doing in school and consider other alternatives. This cannot be over-emphasized.***

Working on a project without any real motivation is not beneficial to anyone in the long run. Staying with a program because you have nothing else you want to commit to can lead to disgust on your part. Do not imagine that your behavior is not noticed. People are just being patient with you until the point where they can no longer be patient. Listen carefully to the clues in the wind!