On graduate studies and research

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Research sounds daunting

- ◆ How can I constantly produce new results?

- ◆ Isn't this an impossible job?

- ◆ I am having a tough time getting done with my thesis, how can I think of doing this as a career?

- ◆ Will I be able to come up with problems to solve all by myself?

- ◆ Am I in the right place?

- ◆ What job should I apply to?

- ◆ How can I succeed in an academic career? …

Lots of topics …

- How do you do research

- Academic careers

- Theory vs. practice

- Funding problems for new faculty

- How to give presentations

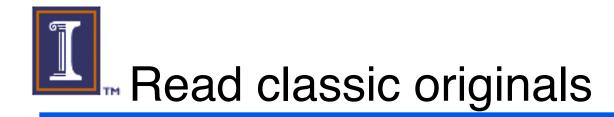- Industry job or university job? Can I switch from one to another?

- ….

Let's start with graduate school

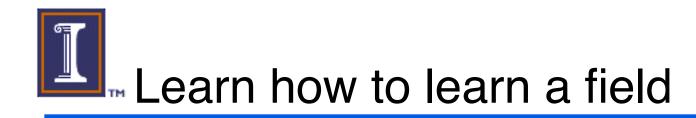# At the beginning of your graduate studies

Get theoretical depth

◆ Luck favors the one who is prepared

◆ Take a solid set of foundational courses

◆ Breadth is important

◆ Depth is perhaps even more important

- Electrical Engineering courses
  » Digital communications, information theory, estimation and detection, coding theory, linear systems, stochastic systems, queueing theory, …
- Mathematics courses
  » Analysis, Graph Theory, Combinatorics, Algebra, Probability Theory, Stochastic Processes, Topology
- Computer Science courses
  » Formal methods, Theory, Operating systems, Network programming

◆ There is no substitute for theoretical depth

Read classic originals

- ◆ Go to the original classics

- ◆ They are richer in ideas than subsequent "compactified" presentations in textbooks, exposes

- ◆ Examples
  - – Blackwell's original papers on dynamic programming
  - – Shannon's original papers on information theory

- ◆ What is an appropriate list for Networking?
- ◆ What is an appropriate list for Computer Science?
- ◆ What is an appropriate list for Systems?

Learn how to learn a field

- Teach yourself

- Learn how to assimilate an entire field all by yourself

- That gives you greater confidence than reading it in a textbook or from someone else

- In the future you will need to learn new areas by yourself
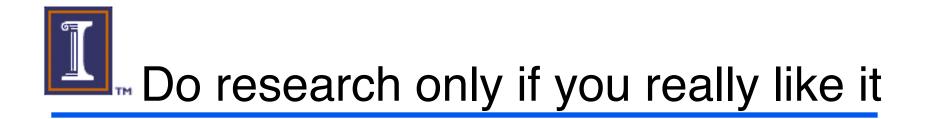
Towards the middle of your graduate studies

Finding the problem is 90% of the problem

- ◆ Research is not just "solving a problem"
  - – Though that too can be formidable research:
    E.g., Solving Fermat's problem

- ◆ What is the field really about?

- ◆ What are the real bottlenecks?

- ◆ What is solvable?

- ◆ What is already known?

- ◆ What is it that is unknown?

- ◆ Why?

- ◆ ….

Later in your graduate studies

Do research only if you really like it
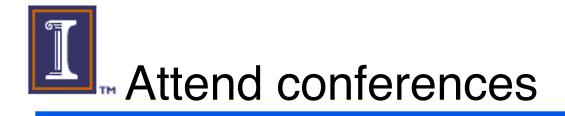
- You need to be very very highly motivated to do research

- There are several other professions to choose from

- Your advisor cannot motivate you to do research

- You should not be in this career because of your parents, …

Period of wilderness

- All (many, some?) graduate students go through a period of wilderness

- A period where you are not sure what you can do

- A period of searching with no light at the end of the tunnel

- Such a "period of wilderness" can be very good for you
  - In fact, I think all grad students need to go through such a period

- That is when you read a lot, you find out where exactly a particular book is on the library bookshelf, or nowadays what papers are on a particular webpage

- It is in this period that you become an "expert"

- Afterwards your students will think your knowledge is amazing

Attend conferences

◆ **Books**
  – Its all done!   ☹

◆ **Conferences**
  – Is this how little is known in this area?   ☺

The importance of making good research presentations

◆ You will get noticed because of your research presentations
  – **In addition to your published papers**

◆ **And of course, there is simply no substitute for good results**

◆ After you have done good work, and written a good paper, you need to present it well

◆ Getting a job can depend on that, and getting noticed can depend on that
  (To repeat, this comes after getting good results and writing good papers)

◆ Clarity of exposition is key

◆ Everything is simple

◆ Show everyone how simple it really is

◆ This takes a lot of work

◆ Frequently you yourself learn more about what you have been thinking when you strive to present it well

Strategic vs. Tactical research

- ◆ Think strategically (perhaps later in your career)

- ◆ Ask how to shape a field or define a field

- ◆ As opposed to how do I extend a result
  - – Though that is also very important

When you are getting ready to graduate

Should you get an academic job or an industry job or a start-up …?

- ◆ There are three extremes: Start ups, Universities, Industry leaders
  - – Everything else is in between

- ◆ If you are thinking about an academic job

  - – Aren't academic jobs nowadays difficult careers, hard to get, …?

  - – How can you constantly produce new results?

  - – Isn't it an impossible job?

  - – I am having a tough time getting done with my thesis, how can I think of doing this as a career?

  - – Will I be able to come up with problems to solve all by myself?

Aren't academic jobs nowadays difficult careers?

◆ You should consider an academic job only if doing research is completely unstressful to you
  – Roughly one PhD Thesis equivalent (or slightly less) every year or so

◆ If it is not the right profession for you, it will be a huge strain on you & family
  – Be honest with yourself
  – Knowing others is intelligence, knowing yourself is wisdom

◆ You should be prepared to spend a lot of time, perhaps most of your time, on your research for the next eight (or some other number of) years
  – Will you be happy doing that?

◆ Research is all consuming: time, effort, attention, and life consuming

◆ You should make research your job only if you love it

◆ If you do like it, it is the best job in the world

Aren't academic jobs nowadays hard to get?

- ◆ A small not well known university may be the best choice!

- ◆ You do not need to start at a top notch university

- ◆ In fact, a small university allows you to establish yourself in an atmosphere which is not a pressure cooker

- ◆ You will eventually equilibrate in your career at a job at as good a university as your accomplishments

- ◆ It is better to be a big fish in a small pond

After you get an academic job

Don't get swamped by teaching

◆ If teaching takes up all your time and swamps you, that is not good

◆ You need to pay attention to your research, and lots of it

◆ At the same time you need to teach well
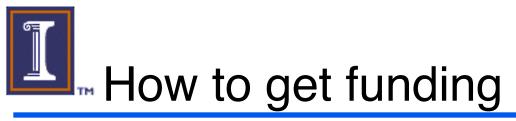
How can one possibly generate research problems?

◆ Several approaches

◆ Let me illustrate a (relatively) easy route

◆ Start with a practical problem, and try to get to the heart of it

- – Practical does not necessarily mean you can apply it tomorrow
- – It means motivated by a real application

◆ The real world is very rich and admits a lot of new ideas

Attend lots of good conferences

◆ About 2 or 3 (or more) a year …

◆ This is where you find out how little is known in a field

◆ You also get to know the people in the research community

◆ Also, you will get noticed through your good work and its presentation

◆ If you cannot get funding, pay for it yourself

An important point about research funding

◆ Most important point

◆ You should get funding to do your research

◆ *Not the other way around*

◆ You should *not* do research so you can get funding

◆ However funding that supports your research is important
  – Supporting graduate students (not too many …)
  – Travel to conferences
  – Getting equipment for your research – computers, lab, ..
  – Secretaries to save your time, so you can do your research

◆ Funding is not the performance metric
  – Except for a few institution builders
  – Who have a vision and want to make that happen (Solomon Lefschetz)

How to get funding

- Getting funding for your research is not magic

- It is a question of writing proposals, talking to program managers

- You just need to talk to peers, senior faculty, etc.

- Find out all the opportunities that there are, and target all of them in a systematic way

- Its just a question of approaching it in an organized way

- In the long run do good work and everything else will follow - funding, students, glory, …

What about tenure?

◆ Do great research

◆ Teach well

◆ Whatever service you are assigned, execute it well
  – Be reliable with respect your service activities

Perhaps later on in your career

Quality not quantity

◆ You will be known by your *best* work

◆ Not by how many papers you have published
  – Later in your career!
  – In the beginning, aim to get published, and get over that threshold first

◆ The norm by which your accomplishments are measured is L_∞ *not* L_1
  – Max {Papers}   rather than Σ Papers

Thank you