PhD Research: Elements of Excellence

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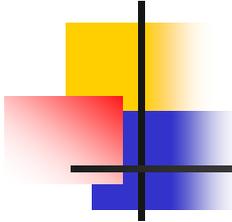
Outline

- Expectations
- Integrity in Research
- Strategies for success
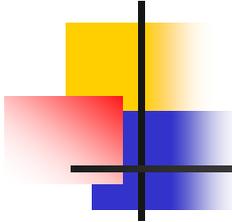
Expectations

- Excellence in course-work is not sufficient
  - Nobody is going to give you a PhD for getting a 4.0
  - Need to do more than simply absorb information
- Need to create new knowledge
  - Impact either in theory or in practice
  - Other researchers/practitioners can build on
- Need to work extremely hard
  - Making progress is difficult
  - Our areas are highly competitive
    - Others may have more experience or be smarter than you
  - But you can out-work them
- Adhere to the highest ethical standards
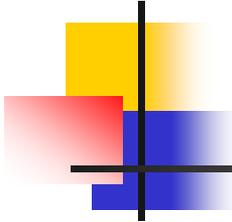
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Integrity in Research

- Plagiarism
- Proper citations
- Mistakes versus Fraud
- Precedence
- Reporting Results…
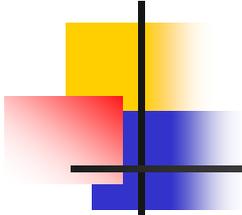
Plagiarism

- Using an idea that does not belong to you
  - You can use someone's ideas with appropriate citation
- Using text that does not belong to you
  - E.g., "borrowing" text from someone's introduction without quotes and citation
- Using software that you do not own
- Is self plagiarizing wrong?
  - Yes

Plagiarism is a very serious offense
and goes to the heart of academic integrity

More details can be found on: http://www.plagiarism.org/
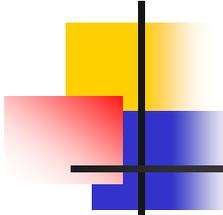
Proper Citations

- Important to cite appropriately
  - Gives credit where it is due
  - Helps to clarify & position one's contribution
  - Increases value of your own contribution
- Citations should not be vague
  - E.g., you shouldn't say "this work looks at a similar problem to [1],[2],[3]
  - Clarify particular similarities and differences
- Do not bury prior work with greatest similarity in a long list of citations
  - Tantamount to plagiarism!
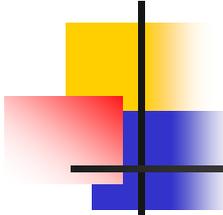
Mistake versus Fraud

- "To err is human…"
  - Occasionally, mistakes can occur
  - Mistakes should almost always be caught before publication (submission) and should only be the exception
- Fraud:
  - Knowingly committing a "mistake" and not correcting it.
  - Misleading your advisor (he/she becomes a victim)
  - Not correcting a genuine mistake
    - Cold fusion (1991), Cloning (2006)…
- If mistake occurs in publication:
  - Admit it and make sure correction is either posted or published
  - "My advisor didn't let me" is NOT an excuse
  - Real-life Example …

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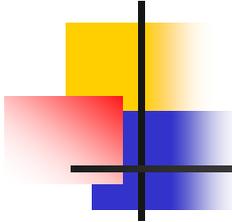
Precedence

- Precedence is very important
  - You spent 12 months on a problem & solved it
  - "Bob" published a paper with the exact same solution before you submitted the work
  - What do you do?
    - A. Try to publish it because it is independent work
    - B. Give up
    - C. Throw a tantrum and leave PhD program
    - D. Extend/modify and find a new angle and publish
  - Real-Life example
- You may choose not to enforce it on others
  - Real-Life example
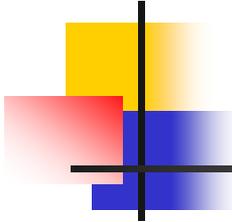
Reporting Results

- Results should be reported accurately
  - Fudging of data is a serious offense (fraud)
  - Sloppy simulations/experiments are unacceptable
    - You and your ADVISOR lose all credibility
- Present the entire picture
  - If there are scenarios where your solution performs poorly or less efficiently, do not hide it
  - Provides more credibility to your conclusions
- Feel free to emphasize scenarios of strength
  - Explain why these scenarios are important
  - You are the salesman/saleswoman of your work
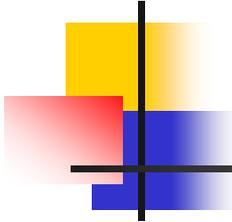
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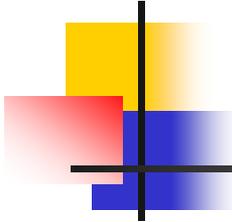
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Strategies for Success

- Self Examination

- Advisor

- Preparation

- Problem

- Solution

- Writing Papers

- Intellectual Climate
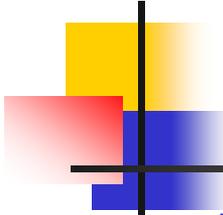
Self-Examination

- Questions you should ask yourself:
  - Are you doing this for the right reasons?
    - Parents want you to earn PhD
    - PhD will get you a good or well paying job...
  - Do you enjoy solving problems/puzzles?
    - Much of what you do for a PhD is working out intricate puzzles
  - Are you tenacious?
    - A PhD is a long-term commitment
    - With very few highs and lots of lows...
- If you answered "No" to the above questions
  - A PhD is not for you
  - Find a more suitable vocation
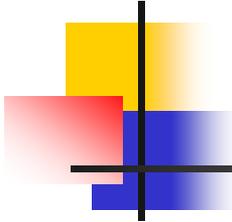
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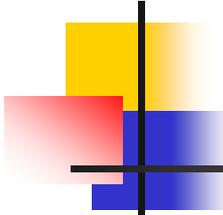
Advisor

- Find an advisor who fits your style
  - Hands on/Hands off
  - Experimentalist/Theorist/Mixture…
  - Junior/Senior
- Give your advisor confidence in you
  - If he/she suggests a problem or solution
    - Think deeply
    - Find alternatives if original idea doesn't work
    - My best students…
  - Do the work at hand, rather than trying to impress
    - Impress with deeds
    - Go well beyond the minimum and superficial
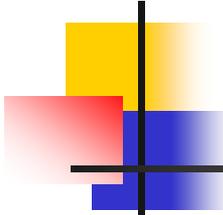
Advisor

- **Challenge your advisor**
  - Feel free to provide opposing points of view
  - My students are not shy to tell me I'm wrong
- **Build trust**
  - If you haven't done any work this week, say so…
  - If you need time off, just ask…
  - Communicate and don't try to deceive
- **☐ Good relationship for life**
  - Recommendations
  - Career opportunities
  - Friendship
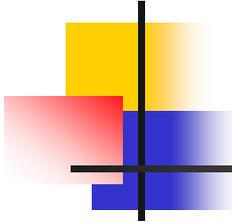
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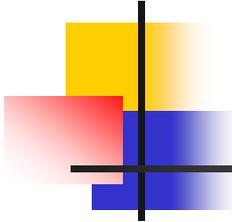
Preparation

- Take a large variety of courses
  - Not only facilitates research but makes you a well rounded scholar (not merely a technician)
  - Classes have been "optimized" to make them efficient tools of learning
    - Hard work is done by someone else
    - Your last opportunity ➔ Make the most of it
  - Challenge yourself
    - Don't shy away from difficult classes in your department and others...
    - Ex. All my PhD students take several advanced Math classes
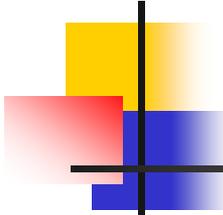
Preparation

- Teach yourself how to self-learn
  - Should be able to pick up any book/paper and work through it
  - Ex. My own graduate students taught themselves advanced optimization techniques, stochastic control, large deviations, & are now experts themselves
- Read voraciously
  - Journals/Conferences
  - Tutorials/Magazines
  - Scientific American
  - Nature...
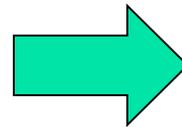
Learn by osmosis
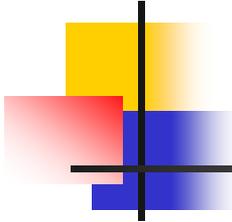
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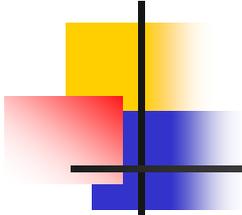
The Problem

- **Most important** part of a PhD
  - Finding a good problem is half the battle
- **Salient** features of a **good** problem:
  - Potential for **high** and **long-term** impact
  - Fills an important deficiency or charts a new direction
  - **Not minor perturbations** of existing systems (802.11, Wireless TCP, HDR, etc.)
  - Is **highly challenging**
    - No matter how smart you are, the problem **should take you time** to solve
    - **Advisors:** Give students the time it takes to struggle through a really difficult problem
    - **Real-Life Example**
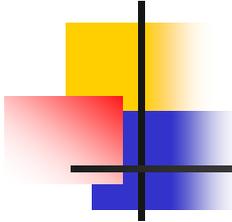
The Problem

- A good understanding of the literature is important in defining the right problem
  - The right problem may find a unique angle or direction that is missing in existing works
- Sometimes helps to think of two problems intermittently
  - Helps get a fresh perspective, when progress on one is not forthcoming
  - However, juggling too many problems simultaneously is usually counter-productive
- Problems can, will, & should get refined once solutions are proposed
  - Assumptions are relaxed or restricted
  - Trivialities found and removed…
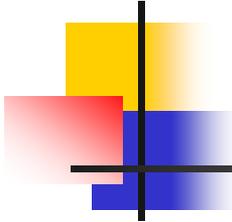
The Problem

- A PhD should not be a union of inconsequential loosely attached problems
  - Must be an overall vision to your thesis
  - Which you should be ready to articulate by the time you are ½ - ¾ of the way done…
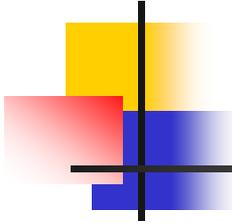
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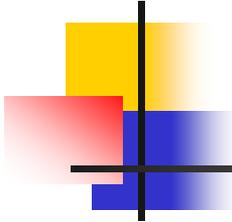
Solution

- Ask your advisor for examples of high-quality papers
  - Get a taste for high quality problems and solutions
  - But don't base your problems or solutions on others' work

- There are no Gods in Academia
  - Learn to read papers written by good people
  - Read strategically & don't become a clone of others'
  - Don't be afraid of solving problems that other top researchers have looked at and failed or only partially succeeded.
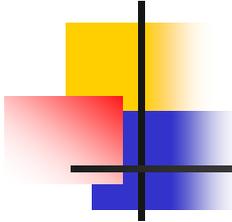
Solution

- Begin with a highly simplified "toy problem"
  - At this stage, it may be better to ignore the literature
- "Own" the simplified problem and its solution completely
  - Incrementally add complexity
- Do not be satisfied with a superficial result
  - Push the problem as far as you can to obtain important theoretical and/or practical results, e.g.
  - Impact of imperfect control in system
  - Implementable, yet provably efficient distributed algorithms…
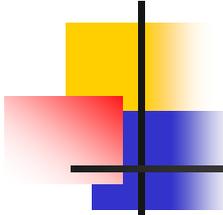
Solution

- Search for elegance
    - A complex unwieldy solution does not make good academic research
    - Even in industry, the elegant ideas are the drivers of innovation
        - Ex., Viterbi algorithm; CDMA, Opportunistic scheduling; Separation theorem, OFDM...
- Search for insights
    - Cross-Layer components can be designed independently
    - Use of queue length information is valuable...
- Never fall in love with the tool (or methodology)
   - Always remember: The problem is King
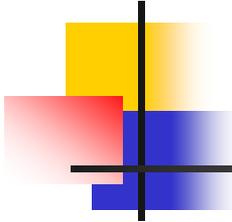
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Writing Papers

- Learn about good writing from high-quality examples in the field
- Read books on writing
  - "The Elements of Style" by Strunk and White for style and grammar
  - "Mathematical Writing" by Knuthe, Larabee, Roberts.
- Write simply and directly
  - Don't use cliché's or arcane/flowery/bombastic words
- Reduce notational complexity
  - Do you really need 3 subscripts and 2 superscripts
- Limit the creation of unnecessary abbreviations
  - Remember advice given to Stephen Hawking
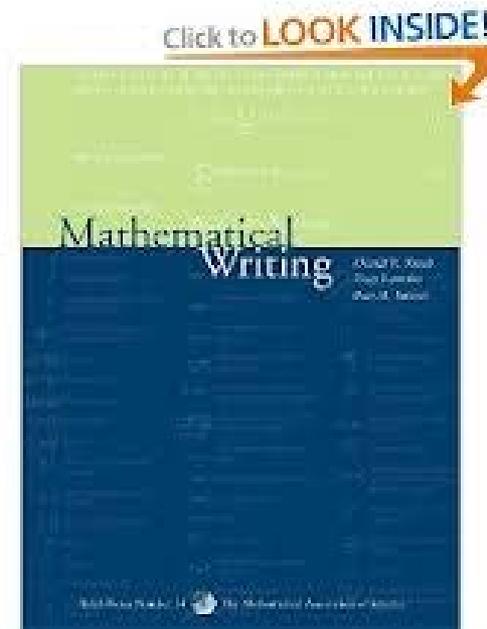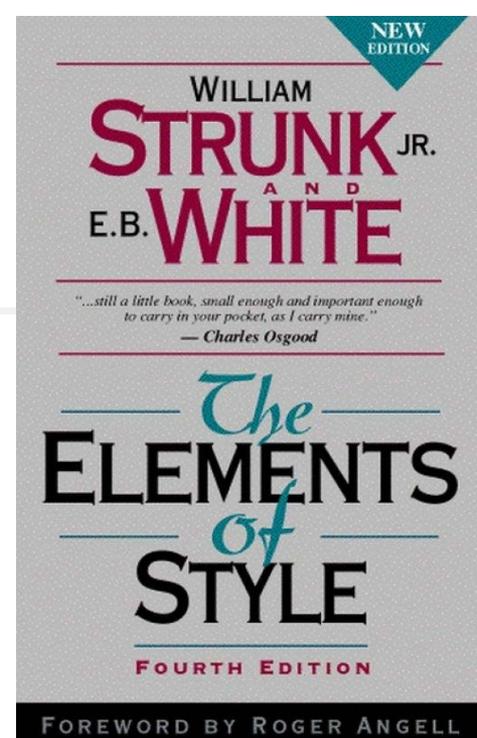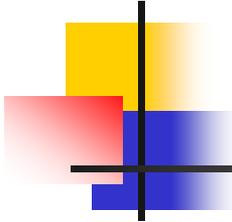
Writing Papers

- Write to explain and not impress.
  - Make the proofs as accessible as possible, supplement with figures
  - Describe main idea before launching into details of system or proof
  - Many excellent technical works out there that never get cited because no one understands them
- Make the paper interesting:
  - Most papers are read by only one other person besides the authors themselves
  - Have a powerful introduction and conclusion
  - What is the one key idea that you want others to take away!
  - You are the salesman or saleswoman of your own work
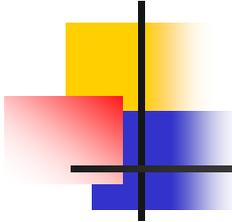
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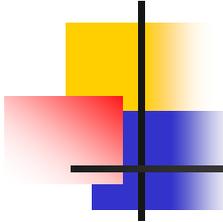
Create an Intellectual Environment

- Go and seek out seminars and presentations
  - Even if they are not in your PhD field of research
  - You are here to be a scholar not just a researcher
  - Push your advisors to give periodic talks, and to invite speakers from industry and academia
- Create your own student-run seminar series
  - Thematic or non-thematic
  - Present/Discuss interesting papers with other students
  - Create an environment where questioning is the norm

Strive for the highest level of scholarship & excellence in whatever you do…

Epilogue

"The power of instruction is seldom of much efficacy except in those happy dispositions where it is almost superfluous"

-- Original quote by Gibson, obtained from Richard Feynman's Lectures on Physics.

Thank you!