How To Do Research in 8 Weeks, Notes by Andy Neureuther June 18, 2008
(Based on a presentation to undergraduates doing summer research at Berkeley)

Disclaimers:

- Research is not easy because it requires getting in-depth knowledge in a field, acquiring relevant skills, adapting your strategy on the basis of initial results, making creative contributions, producing new results for the field, and going back and double checking your assumptions,
- Every project is different and no one formulation applies. In some cases you may be gathering some of the first data on which models will later be built, in other cases you may be assessing implications from models. Some of you may simplifying models for higher levels of abstraction and integrations. Others may be proving theorems based on assumed properties or emulating the performance of a system.

First Week: Research Identification, Group Rapport

- One key to success is to cleanly identify the research attributes
    - Technical problem: Open (new knowledge) research question and why obtaining this information is important.
    - Your approach: (experimental, simulation, theory) (operational process and what is not done before)
    - Scope of what you plan (for now) to look at
    - Significant Accomplishment you plan to achieve (new theorem, new set of data, quantitative characterization information)
- Based on this identification it is possible to write the Abstract for your summer project at the end of the first week.
    - I recommend creating a single sentence that succinctly covers the four points above (20 words or less. This is your elevator talk.)
    - Then add a sentence on motivation (Thank you Sheila.)
    - And follow with one sentence each with more detail on approach, scope and anticipated result.
    - In addition to the above you need a title (shorter is better so work the first sentence down to < 8 words.)
- Establishing good working rapport with your fellow researchers is also a key
    - Ask for a couple of articles to give you background
    - Ask questions so that other know where your are in coming up to speed and can give you the right level of help
    - Try to add value by throwing out ideas and suggestions

Second Week: Pilot's License on Approach and Game Plan

- Be sure that you have the background and practice the skills to execute the approach and test your self on simple cases. (Run simulator, work out formulation for a simple case, use model to predict the shape of the curves you will measure)
- Develop a summer research work Game Plan
    - This is a week-by-week plan of action with an estimate of the level of effort required (Remember it always taks 2X what you think)

    - Always have 3-4 actions in play incase you hit snags on one and so you can rotate them every couple of hours to stay fresh

Third Week: First Results and Screening

- Look at the more extreme situations to see if the approach will work, the overall trends, and what is interesting.
- From the overall trend identify which aspects are most interesting (novel, useful, exciting)

Fourth Week: Drive the Heart of the Research

- Try to get the anticipated result (theorem, experimental understanding, systematic characterization)

Fifth Week: Mid-Course Maneuver

- Assemble the information and a presentation for a review by others in your group (Plug any holes that this reveals to you.)
- Give the presentation and brainstorm and critique with others
- Are you working smart? (80% of the results can often be obtained with 20% of the effort)
- Re-Plan the scope based on what is most important, what you can contribute best and time remaining

Sixth Week: Drive the Research to the re-targeted Anticipated Results

- You are an expert on this research now and are 5x more productive than the first two weeks (It is not unusual to have to quickly re-do much of your earlier work now that you have improved the methods, assumptions, etc.)
- Focus on the value to others from your research
- Deliver results commensurate with the level of effort and cost

Seventh Week: Pull the technical content together

- Assemble your results in to a systematic flow and make an interpretation
- Notice any missing information or needs for data to support your interpretation and fill them if you can
- Outline and write a full draft of your report

Eighth Week: Polish, Present and Report

- Patch any glitches in the data or interpretation
- Organize a poster/talk
- Give the talk/poster
- Update the report based on brainstorming and feedback from presentation

Each Week:

- Read two relevant articles from the literature
- Ask two in-depth questions about the research
- Create two keep slides for your poster

Final Report:

- Use the Abstract from Week One and updated it according to how the research unfolded. (Most conferences will not accept a paper unless the abstract includes evidence that the claimed accomplishment has been achieved. Often this is a quantitative result that shows that the approach works and reveals what is interesting about your results.
- Introduction 3 Paragraphs
    - PP1 is motivation (what used for, the nature of the information that is needed {sort of a hit at the knowledge gap you will fill)
    - PP2 is history of work in the field (give 3-8) key references in the field and present them in an overall perspective on approaches and results.
    - PP3 Contribution and paper flow (This paper presents … Section 2 describes … Consideration of xx and yyy is then covered in section 3.
- Section on Approach
    - Provide enough information that the reader could reproduce the research. (The real test of science is that someone else could reproduce the result from the information that you give. If it is not reproducible it is not science.)
    - But do not give a tutorial on the field.
- Section on Results
    - Use a lead in paragraph on the scope
    - Then work figure by figure with about one paragraph per figure.
        - Say what the horizontal and vertical axes are
        - Say what the curves are (if more than one)
        - Discuss overall shape trend
        - Discuss quantitative level and significance
- Conclusion
    - Two paragraphs maximum
    - Determine the most important 3-5 results to put the overall work in perspective
    - One sentence or two from each section (yes include how well the approach worked, as well as the 3-5 most important results)

Poster: (There are several handouts on file about posters)

- Determine the number of panels and if the title consumes a panel
- One panel each for
    - Overview (investigated xxx, using yyy, and explored aspects A, B, C)
    - Problem Statement (more specifics)
    - Motivation
    - Approach
    - Conclusion (how well method worked and most important 3-5 results)
- 7-11 panels on results grouped in sets according to aspect A, B, C
    - Panel on specific case and assumption considered
    - Panel showing data trend
    - Panel discussing trend