

# Some words of advice for research students (and advisors!)

- Professor Arun S. Mujumdar
- Mechanical Engineering Department
- National University of Singapore
- and
- Adjunct Professor, Departments of Chemical and Bio-systems Engineering
- McGill University, Montreal, Canada

# Outline

- General thoughts
- Research Area- selection
- Know your area of research
- Conducting research- experimental vs computational
- Dissemination of research results
- Closing Remarks

# Research Area- How to choose?

- Choice of institution, advisor etc-beyond scope of this discussion
- Key criteria: your interest area, future prospects (at best good guesses), funding availability, your expertise and resources available
- Excellence, reputation, visibility, expertise, experience of advisor can affect outcome
- Younger faculty desirable for newer ,hot areas!

# Know your research area well

- Must conduct thorough, up-to-the-minute literature review
- Review must be critical- do not read literature like a novel or newspaper!
- Write a review- not a list of papers!
- Identify "gaps" if any. Find out why these gaps exist. Is it worth filling them ? Or, best left alone?
- List objectives and scope realistically. Must have some engineering significance if and when accomplished.

# What should you know?

- Almost everything about the sub-area for PhD students
- A lot of about the area itself
- A significant amount about the discipline and how your research theme fits into it
- Keep up on weekly basis with literature- typically need to scan 30-40 journals, conference proceedings, theses etc just to stay abreast in most areas
- Unless one does above it is unlikely one can make an original contribution.
- Note: Original does not mean “beyond your own knowledge of the field”-this should be easy to achieve by not knowing what is already done!

# Examples-what one must know

- Area: Spray drying –modeling
- Sub-areas: CFD, spray drying technology, different modeling approaches, single and multiple particle trajectory and drying rate calculations, morphology of dried powders, particle characterization etc
- Discipline: Chemical, Food or Mechanical Engineering-preferably inter-disciplinary

# Example 2

- Sub-area: Pulse combustion drying-modeling
- Areas: CFD, combustion kinetics, pulse combustion, drying, spray drying, droplet drying, high temperature heat transfer, noise, etc
- Discipline: Mechanical/ Chemical Engg.

# Anything else?

- Yes, must be thorough in fundamentals e.g. transport phenomena, numerical methods, experimental techniques, design of experiments, statistical analysis of data,
- Be familiar with seminal/ classical references and text-books. Remember names of key persons, institutions, locations etc
- Develop global network of contacts



# Math Modeling-oriented research

- Why model? Not just to simulate already known experimental data but to extrapolate ,interpolate it with confidence and use it to enhance speed of innovation process by fast and inexpensive testing of uncharted design concepts.
- Must show validity of model- various ways possible depending on area

# More on modeling

- Remember optical fibre idea was proven via math modeling- took 10+ years to devise first optical fibre based on it
- Different levels of modeling possible- develop simple model –not simpler
- Model must mimic key features e.g. transient nature of an unsteady phenomenon
- Integral tests are easy but not definitive- integration is an error-smoothing process!

# Experimental research

- Design experiment well and to right scale to get proper accuracy, resolution and scale
- Statistically analyze data. Check reproducibility. Estimate uncertainty
- Must be aware of alternative ways to test and measure parameters
- Minimize error. Report enough information on design and measurement for reader to reproduce data.

# Experimental research-2

- If prior data exist to benchmark against, do that first step
- If model exists that can be used to predict results obtained ,test data against it
- Do not discard data that do not fall in line with expectation, intuition or pet model- these may be the only correct data! Discard data only if there is clear reason for it.

# Closing Remarks

- Literature review and preparation of papers for dissemination at conferences or in journals – covered elsewhere
- Report on-going work in conferences and final ,finished product in peer-reviewed journals
- Be ethical in conducting research and reporting it- your long term professional well-being will depend on it!

# Editor's Dilemma

- Referee's comment on a paper sent for review:
- *This paper contains something that is new and some thing that is true. Unfortunately, what is new is not true and what is true is not new.*

# Closure

- Thank you for your attention
- Any questions?