A Course on Research Methodology

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Disclaimers

'If to do were as easy as to know what were good to do, chapels had been churches, and poor men's cottages princes palaces. It is a good divine that follows his own instructions: I can easier teach twenty what were good to be done, than be one of the twenty to follow mine own teaching.'

William Shakespeare

'He who can, does. He who cannot, teaches.'

George Bernard Shaw



Introduction



Research

Definitions.

Online Oxford Dictionaries.

- In the noun form:
  the systematic investigation into and study of materials and sources in order to establish facts and reach new conclusions.
- In the verb form:
  investigate systematically.
- Origin:
  late 16th century: from obsolete French recerche (noun), recercher (verb), from Old French re-(expressing intensive force) + cerchier 'to search'.

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- Research can be defined as the search for knowledge, or as any systematic investigation, with an open mind, to establish novel facts, usually using a scientific method.



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Methodology

Definitions.

Online Oxford Dictionaries.

- Noun: a system of methods used in a particular area of study or activity
- Origin:
  early 19th century: from modern Latin methodologia or French méthodologie

Wikipedia (extracts).

- Method can be defined as a systematic and orderly procedure or process for attaining some objective.
- Methodology specifies several processes that need to be followed. These processes constitute a generic framework.
- Methodology may refer to the rationale and the philosophical assumptions that underlie a particular study relative to the scientific method.



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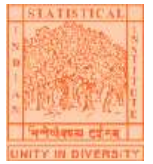
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Purpose and Outline



Purpose of the Course

- To familiarise students with the different aspects of research.
- To provide an idea of good scientific writing and proper presentation skills.
- To provide an understanding of philosophical questions behind scientific research.
- To provide a brief background on the historical legacy of science.

- Focus on research in mathematical and engineering sciences.
- Portions may be relevant to other subjects.
- Pointers to reading material will be mentioned during the course.



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Organisation and Assessment

- Lectures by the instructor.
- Lectures by other guest lecturers.
- Presentations by the students and panel discussions among the students.
- The course will consist of about 30 sessions (lectures, discussions, student presentations) each of 1.5 hours duration.
- Sessions will usually be conducted twice weekly.
- Assessment will be based on written assignments and on the participation in the discussions and lectures.
- Final evaluation will be given as a grade and successful/unsuccessful completion of the course will be indicated.



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Based on the objectives, the course has been divided into two parts.

- General discussion on different aspects of research.
- History and philosophy of science.

The two parts will run simultaneously.
One lecture per week for each part.



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General Discussions

Focus on early-career research as opposed to mid-career research.

- Lecture 1:
  - Motivation for research.
  - Building a background.
- Lecture 2:
  - Role of a supervisor.
  - Time and energy management.
- Lecture 3:
  - Finding a problem.
  - Solving a problem.
- Lectures 4 and 5:
  - Writing a paper.



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  - Publishing.
  - Reviewing a paper.
- Lecture 7:
  - Scientific ethics (or norms and conventions).
  - Collaborative work.
- Lecture 8:
  - Presentation skills.
- Lecture 9: miscellaneous.
  - Bibliometrics.
  - Recognition, awards and prizes.
  - Research funding.
  - Intellectual property rights.
  - Politics in the research environment.



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Lectures on Special Topics

- Role of intuition in research.
- Role of abstraction in research.
- Using mathematics as a tool.
- Basing research on data.



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Some References on General Advice

- The blog of Terence Tao.
- Transcription of a talk entitled “You and Your Research” by Richard Hamming.
- ‘How to Solve It’ by Polya.
- Gian Carlo Rota’s article in AMM.
- There are other good online material.



History and Philosophy of Science

- The rise of science (in Europe): concept of the heliocentric universe as a revolution, simplification via Occam's razor.
- Deductive method. Broad-sense and narrow-sense interpretations of scientific and logical methods.
- Modern inductive method (Bacon), Mill's method of induction, positivism (Comte), logical positivism, statistics as a universal method of induction.
- Popper, Kuhn, Feynman.



History and Philosophy of Science

- Epistemology (briefly): Plato/Aristotle, Descartes, Locke/Berkeley/Hume, Wittgenstein.
- Epistemology (briefly) in the Indian philosophical systems.
- A brief history of mathematics: Euclid, Archimedes, Fermat, Newton, Gauss, Galois, Abel, Hilbert, Ramanujan, Kolmogorov, von Neumann.
- Some important scientific advancements.
- A brief history of mathematics and science in India.



Some References

- Portions of “A History of Western Philosophy” by Bertrand Russell.
- Richard Feynman. “The Meaning of it All”.
- Wikipedia.
- Stanford online encyclopedia of philosophy.
- Other sources.

