Research Methods in Computing: Introduction

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1

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A note on this series of lectures

This course is designed for post-graduate students in computing science and has three interlinked objective:

1. **First, to describe the distinctive nature of research in computing, a subject with substantive application and significant intellectual challenge.**
2. **Second, to introduce the students to the emerging discipline of knowledge management so that the student can appreciate how knowledge flows in organisations and in the society at large – causing the frequent paradigm shifts in computing.**
3. **Third, issues related to the furtherance of research through peer-reviewed support and encouragement.**

The students will be able to discuss the matters outlined above with speakers, drawn from academia and industry, during seminars given by the speakers. The speakers will refer to their own career choices in computing.

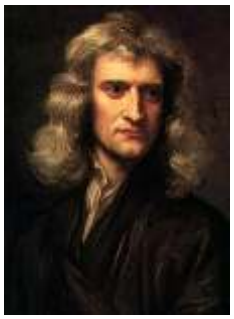
Some definitions

RESEARCH: A systematic search for facts; scientific investigation

Some definitions

RESEARCH:

I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the sea-shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me



Be modest acronyming

•One thing you should think about is the naming of programs, methods, techniques and data sets you may have created.

•Enrico Fermi, a Nobel Prize winner, full-professor at the age of 27 years, original contribution to 10 major fields in physics ranging from general relativity to quantum theory, and from nuclear physics, solid state physics and extra-terrestrial life. He died when he was 54 years of age.

•Inventor of the self-sustaining nuclear reactor built in the 1930's, one of the creators of the atomic bomb, originator of semi-conductors.

•Almost invariably avoided naming using his own names.

•Let us look at this pinnacle of humility and one of the grand scholars of the 21st century

Be modest acronyming

Physical domain	Fermi's eponymous designations (compound terms) in English
Atomic Physics	Thomas Fermi Model and Thomas-Fermi Equation
Cosmic Ray Physics	Fermi's mechanism; Fermi's Landing (?)
Elementary Particle Physics	Fermionic Field; ant-Fermion; Fermi-Yang Model; Fermi diagram, Fermi transitions and Fermi Selection Rules; Fermi's Universal Constant, Fermi's Theory
Extra-Terrestrial (Life) Research	Fermi's Paradox
General Relativity	Fermi co-ordinates; Fermi derivatives; Fermi's Transport; Fermi's co-efficient of revolution/rotation; Fermi's Principle of Weak Equivalence
Molecular Physics	Fermi's Resonance
Nuclear Reactor Physics	Fermi's Age; Fermi Pile
Quantum Mechanics & Many-body Physics	Fermi Golden Rule, Fermi Gas; Fermi's Liquid; Fermi's Surface
Statistical Quantum Mechanics	Fermi-Dirac Statistics and distribution function; Fermi Energy; Fermi's Impulse, Fermi's Temperature; Fermi's Condensation
Solid State Physics	Fermi's Hole; Fermi's Sphere; Fermi velocity; Fermi's wave-vector

Be modest acronyming

Eponym	Description
Fermions	Obey Fermi-Dirac Statistics and now comprise quarks, electrons, nucleons, neutrinos and nuclei.
Fermio –	An unstable element, atomic number 100
Fermi and Femtometer	A new unit of measurment of length – *fermi* measured in femtometre: 1 million billionth of a meter

Some definitions

RESEARCH:

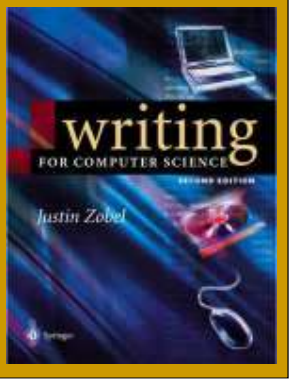
You think; you reflect; you write; you revise; you communicate; you receive feedback; you think; you reflect…..

Doing Science?

RESEARCH:

You think; you reflect; you write; you revise; you communicate; you receive feedback; you think; you reflect.....

Many books on how to write:
Check this one out



Course Outline

Introduction

- Research in Computing
- Hot papers in Computer Science
- Computing as a professional discipline
- Paradigm Shifts
- How to Write a Research Proposal
- Plagiarism
- Patents

Knowledge Management

- Knowledge of People and Organizations
- Corporate Learning
- Knowledge Creation Crew

Biographical Lectures

- Lectures by CS Staff – what did I do to become what I am?

Coursework

Project: How to write a Research Proposal

Objective: To write a proposal for a research funding agency

Work Mode:	**Team work (2-4 per team)**
	Poster Presentation
	Press Release
Evaluation:	**50% marks on Poster Presentation**
	40% marks for an Oral Examination
	10% marks for a Press Release
Deadlines:	**Report Submission: 1st June 2011**
	Presentation: 10th June 2011 onwards (TBC)

Doing Science?

RESEARCH:

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Many websites on how to write a CS thesis:

A quirky one is by my good friend Professor Aaron Sloman:

http://www.cs.bham.ac.uk/research/projects/poplog/teach/theses

Doing Science?

RESEARCH:

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Good communication is extremely important –

WHAT IS YOUR RESEARCH QUESTION?

(Takes about 6-12 months to define and you have to refine the question over the next 24-36 months)

ALWAYS BE SURE TO ACKNOWLEDGE OTHERS

Doing Science?

RESEARCH:

You think; you reflect; you write; you revise; you communicate; you receive feedback; you think; you reflect.....

Good communication is extremely important –
Motivate the reader
Structure the thesis

- Introduction → Birdseye view of your work and its context
- Literature Review → What motivated you? Set the scene/produce a critique
- Method → How will you do what you have to do?
- Experiments & Evaluation→ Does your method work?
- Afterword → What happened? Wins and Losses?

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Doing Science?

RESEARCH:

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Good communication is extremely important –
Motivate the reader
Structure the thesis – Make it look like a fish

Introduction →	Fat
Literature Review →	Fatish
Method →	Fat
Experiments & Evaluation→	Fatish
Afterword →	Thin

Tuna like

ALWAYS BE SURE TO ACKNOWLEDGE OTHERS

Doing Science?

RESEARCH:

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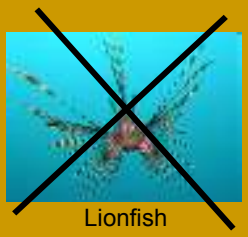
Good communication is extremely important –
Motivate the reader
Structure the thesis – Make it look like a fish

Introduction →	None
Literature Review →	Fatish
Method →	Fat
Experiments & Evaluation→	Fatish
Afterword →	None



Lionfish

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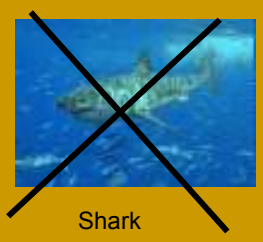
Good communication is extremely important –
Motivate the reader
Structure the thesis – Make it look like a fish

Introduction →	Thin
Literature Review →	Fat
Method →	Fat
Experiments & Evaluation→	Thin
Afterword →	Sprawling



Shark

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Good communication is extremely important –
Motivate the reader
Structure the thesis – Make it look like a fish

Introduction →	Fat
Literature Review →	Fatish
Method →	Fat
Experiments & Evaluation→	Thin
Afterword →	Thin

Shark

ALWAYS BE SURE TO ACKNOWLEDGE OTHERS

Doing Science?

RESEARCH:

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Many websites on how to write a CS proposal:
http://research.microsoft.com/Users/simonpj/papers/Proposal.html

Doing Science?

NO	YES
The object under study was displaced horizontally	The ball moved sideways
On an annual basis	Yearly
Endeavour to ascertain	Find out
It could be considered that the speed of storage reclamation left something to be desired	The garbage collector was really slow

Doing Science?

Resource Overbooking and Application Profiling in a Shared Internet Hosting Platform

BHUVAN URGAONKAR
The Penn State University
PRASHANT SHENOY
University of Massachusetts
and
TIMOTHY ROSCOE
ETH Zürich

In this article, we present techniques for provisioning CPU and network resources in shared Internet hosting platforms running potentially antagonistic third-party applications. The primary contribution of our work is to demonstrate the feasibility and benefits of overbooking resources in shared Internet platforms. Since an accurate estimate of an application's resource needs is necessary when overbooking resources, we present techniques to profile applications on dedicated nodes, possibly while in service, and use these profiles to guide the placement of application components onto shared nodes. We then propose techniques to overbook cluster resources in a controlled fashion. We outline an empirical appraoch to determine the degree of overbooking that allows a platform to achieve improvements in revenue while providing performance guarantees to Internet applications. We show how our techniques can be combined with commonly used QoS resource allocation mechanisms to provide application isolation and performance guarantees at run-time. We implement our techniques in a Linux cluster and evaluate them using common server applications. We find that the efficiency (and consequently revenue) benefits from controlled overbooking of resources can be dramatic. Specifically, we find that overbooking resources by as little as 1% we can increase the utilization of the cluster by a factor of two, and a 5% overbooking yields a 300–500% improvement, while still providing useful resource guarantees to applications.

Bhuvan Urgaonkar, Prashant Shenoy, Timothy Roscoe (2009). Resource overbooking and application profiling in a shared Internet hosting platform. *ACM Transactions on Internet Technology (TOIT)* Volume 9 , Issue 1 (February 2009)

Doing Science?

http://www.plainenglish.co.uk/

http://www.plainenglish.co.uk/DrivelDefenceText.html

Doing Science?

Doing Science?

Doing Science?

Research and philosophizing

You think; you reflect; you write; you revise; you communicate; you receive feedback; you think; you reflect.....

The American way: You publish or you perish

The European way: Some will publish to help others survive

Research and philosophizing

You are philosophizing – because?

You are studying or following or developing a particular system of ideas or beliefs relating to the general scheme of existence and the universe;

You are studying a philosophical system or theory;

You are studying or creating a set of opinions or ideas held by an individual or group;

You are studying or developing a theory or attitude which acts as a guiding principle for behaviour; an outlook or world view

Research and philosophizing

You are philosophizing – because?

You are studying the general principles of a particular subject, phenomenon, or field of inquiry;

And were you to be starting your thesis, say 100-150 years ago, then you would be conducting rational inquiry or argument, rather than following divinely revealed knowledge.

Research and philosophizing

You are philosophizing – because?

But the term *rational inquiry* does not quite describe research in the 21st century, or as some may argue, at any time in the past.

Creativity, the influence of the immediate physical, social, and political environment, personality and many other factors can influence an individuals' research.

Research and philosophizing

You are philosophizing – because?

Philosophy in general, and philosophy of science in particular is replete with many *isms*.

The more well-known 'ism' is *rationalism:*

***According to the OED: Rationalism is* [t]he doctrine or theory that emphasizes the role of reason in knowledge, or claims that reason rather than sense experience is the foundation of certainty in knowledge.**

Research and philosophizing

You are philosophizing – because?

Philosophy in general, and philosophy of science in particular is replete with many *isms*.

The other well-known 'ism' is *empiricism:*

***According to the OED: Empiricism is* [t]he doctrine which regards experience as the only source of knowledge**

Research and philosophizing

You are philosophizing – because?

Philosophy in general, and philosophy of science in particular is replete with many *isms*.

The other well-known 'ism' is *positivism:*

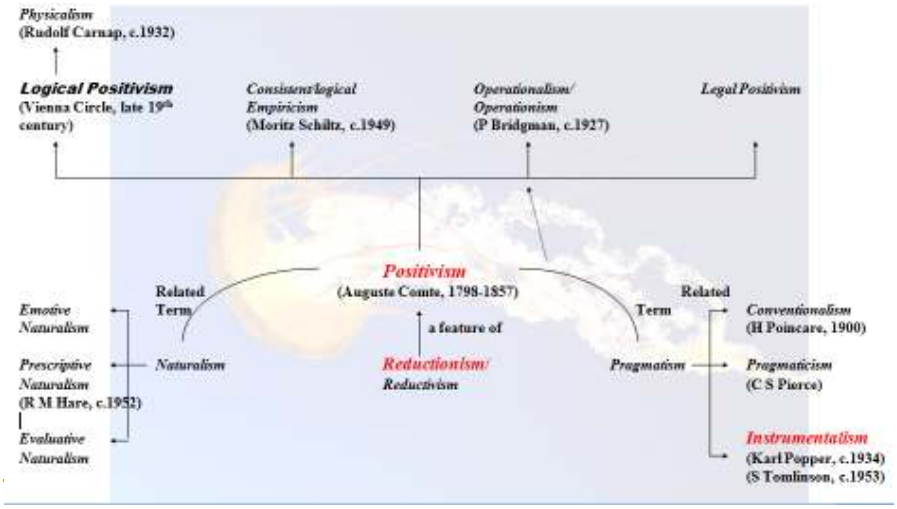
***Positivism is* any of various philosophical systems or views based on an empiricist understanding of science, particularly those associated with the belief that every cognitively meaningful proposition can be scientifically verified or falsified, and that the (chief) function of philosophy is the analysis of the language used to express such propositions**

Research and philosophizing

In philosophy of science one can find upto (and perhaps more than) 200 different isms

TERM	ELABORATION	First reported
Naturalism	All phenomena can be explained in terms of natural causes and laws without attributing moral, spiritual or supernatural significance	1750
Realism	Universals exist independently of being thought (as opposed *idealism*).	1817
Positivism	Sense perceptions are the only admissible basis of human knowledge and precise thought. After Comte's	1854
Physicalism	All phenomena can be described in spatio-temporal terms: any descriptive scientific statement can, in principle, be reduced to an empirically verifiable physical statement	1869
Relativism	A theory that conceptions of truth and moral values are not absolute but are relative to persons or groups holding them.	1885
Pragmatism	The doctrine that the meaning of an idea lies in its observable practical consequences.	1898

Research and philosophizing



Research and philosophizing

You are philosophizing – because?

- Discovery in science revives and sustains it, and its explanations are many and varied. For Ludwick Fleck (1913-1967) and Thomas Kuhn, it is the social network of scientists that motivates discovery. Fleck talked about 'thought styles' and 'thought collectives' within a subject domain, which 'may also be accompanied by a technical and literary style characteristic of the given system of knowledge' (1979:99).

Fleck, Ludwick (1979). *Genesis and Development of a Scientific Fact.* Chicago: Univ. of Chicago Press. (Originally published 1935).

Research and philosophizing

You are philosophizing – because?

- **A *research paradigm* was defined originally by Kuhn (1970) to 'suggest that some accepted example of actual scientific practice - examples which include law, theory, application and instrumentation together - provide models from which spring particular coherent traditions of scientific research' (1970: 10).**

KUHN, T. S.(1970).The Structure of Scientific Revolutions. Chicago: Chicago Univ. Press.

Research and philosophizing

You are philosophizing – because?

- **Kuhn talked about *normal science* and *scientific revolutions*.**
- **There are long periods when tenets of a given scientific doctrine are taken as read and scientists refine existing theories, build instruments to show how truthful the theory's predictions are or that the instrumentation leads to unexpected discoveries that confirm the existing orthodoxy even further.**

KUHN, T. S.(1970).The Structure of Scientific Revolutions. Chicago: Chicago Univ. Press.

Research and philosophizing

You are philosophizing – because?

- **Kuhn talked about *normal science* and *scientific revolutions*.**
- **Then there is a period of shorter duration when existing theories are rejected, new theories are proposed, extant instrumentation leads to the rejection of extant theories. A new order is established complete with its jargon, that is accepted as terminology later.**

KUHN, T. S.(1970).The Structure of Scientific Revolutions. Chicago: Chicago Univ. Press.

Research and philosophizing

You are philosophizing – because?

- Kuhn's paradigm shifts during the 'revolutionary' periods in science (1962) have been well documented and challenged. In his later writings, Kuhn talked about a lexicon or 'lexical structure of science which is the long-term product of the "tribal experience" of scientists in "natural and social worlds"' (1993:330).

Kuhn, Thomas (1962). *The Structure of Scientific Revolutions*. (2nd Edition). Chicago: Chicago Univ. Press
Kuhn, Thomas (1993). 'Afterwords'. In (Ed.) Paul Horwick *World Changes: Thomas Kuhn and the Nature of Science*. pp.311-341.

Research and philosophizing

You are philosophizing – because?

- For the positivist philosophers, it is the logical rather than societal evolution of science which should be of concern to us. Karl Popper proposed a schema for the 'growth of knowledge through error elimination by way of systematic rational criticism (1979:121).

Popper, Karl R. (1979). *Objective Knowledge: An Evolutionary Approach*. Oxford: The Clarendon Press.

Doing science

RESEARCH:

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- **I would like to briefly (!) describe my favourite description of what I understand research in computer science is.**
- **I would like to talk about good and 'bad' research papers in CS**
- **I would like to talk to you about how to write a research proposal; slotted time is limited so perhaps we can do some group-work?**