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What is Research

Ronald I. Frank

Pace University, Ivan G. Seidenberg School of Computer Science and Information Systems

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T E C H N I C A L R E P O R T

Number 218, September 2005

What Is Research?

Ronald I. Frank

Ronald I. Frank

**Information Technology Researcher and Innovator, Senior R & D Project Manager, International Consultant,
R & D Business Chairman & CEO, and Life-long Educator.**

IBM

- I. Research Division staff member, manager & corporate-board consultant
- II. Principal IBM US spokesman/consultant for the engineering and scientific PC
- III. Scientific Center staff member / project manager and staff member & Computer Center Manager
- IV. District and Branch Offices Scientific Marketing Rep.
- V. Service Bureau Development Programmer: commercial & scientific applications

IBM Projects

- I. Corporate-board consultant [educational uses of the internet]
- II. Research manager of parallel computer interfaces
- III. Research manager of low-end APL
- IV. Research staff member (APL language and Virtual Reality research)
- V. Team created the first Remote Operation of [370/3090 Main Frame] Computers
 - VM OS Programmable Operator component.
- VI. Team created first modern LAN Network Management.
- VII. Team developed the first WAN line quality monitoring technology.
- VIII. APL Development team - Earliest "Home Use" Of Personal Computers
 - Developed Scientific and Engineering applications for "proto personal computers".
- IX. Manager IBM Systems Research Institute Computing Center [Grad School & Research Center]
- X. Scientific Marketing Consultant to ~10% of US Industrial Research. (Esso (sic), ATT, Bell Labs, General Dynamics Electric Boat, etc.)
 - Special Scientific rep to the University of Pennsylvania / Consultant to Provost on developing a computing facility for Academic/Scientific use
 - Created some of the earliest courses and taught IBM-ers and customers what computers were and how they could be used.

Entrepreneurial Business Experience

IMMERSIVE SYSTEMS INC. (A virtual reality R & D company) Chairman and CEO

EDUCATION

Pace University School of Computer Science & Information Systems DPS in Computing.

New York University Courant Institute of Mathematical Sciences Ph.D. Student In Applied Math as an *IBM GRADUATE RESIDENT FELLOW*. MS Applied Math & Ph.D.-"ABD".

Rutgers University BA, Math

ACADEMIC EXPERIENCE (Undergraduate and Graduate Level)-

Massachusetts College System & Pace University All courses in CS & IS & Telecom.

HOBBIES

I like to hike the Westchester North County Trailway, snorkel, and read science fiction - not all at the same time.

The slides shown here are used by Dr. Frank in beginning lectures on research to students at the start of the Doctor of Professional Studies in Computing program.

Research is centerpiece to the D.P.S. Students are lead into their dissertation through a series seminars that starts in their first semester. The first seminar, DCS891A, examines the nature of scientific investigation, the different types of inquiry, and the processes of selecting a dissertation topic, conducting a review of the literature, and drafting a proposal.

Dr. Frank is an active contributor to all D.P.S. research activities. He is currently the chairperson of two dissertation committees as well as a member of five others.

The October 2005 Technical Report will present a description and an assessment of the D.P.S. The assessment includes an evaluation of the emerging doctoral dissertations relative to the significance of the problems, the strength of their investigative methodology, and their readability.

Helpful Instruction



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What is Research?

THE START

325 Goldstein AC PV
& 416A WP GC
rfrank@pace.edu

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	Typical Dissertation Outline	
	* Non-Equilateral Regular Array	

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Prelude to Research - 1

How Does Humanity Itself Learn?

RESEARCH

Ideas:

- Better to get your own that YOU are interested in
- Can come from you advisor – last resort

Criticism:

- Experts (advisor) provide only opinion – Theirs
- NOT A LAW OF NATURE
- *You must teach your committee and your advisor*
- You know the work better than they do

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Prelude to Research - 2

Tricks of the trade - 1

Notebooks:

- Wear underpants, shoes, and your notebook
- \$25 pocket recorder in your pocket & at bedside

Experiment: Watch TV for 10 Minutes w/sound OFF

- Count scene changes / minute in old movie
- Count scene changes / minute in new adventure
- *Your concentration has been rotted by TV*

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Prelude to Research - 3

Tricks of the trade 2

Conscious use of your unconscious

- **Jacques Hadamard “The Psychology of Invention in the Mathematical Field” (~\$9)**

Dover ISBN 0-486-20207-4

- **Henri Poincare “Science and Method” (~\$16)**

Dover ISBN 0-486-243269-6

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Prelude to Research - 4

Self Esteem - 1

Shopping Cart

- Middle aged women conceived of a folded pocketbook w/frame & wheels that becomes a shopping cart (city type).
- Family and friends ridiculed idea.
- 20 Years later it became a \$million seller.

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Prelude to Research - 5

Self Esteem - 2

Computer Mod of Sewing Patterns

- Middle aged women conceived of using a standard sewing pattern and computing the changes for a specific person – a computer home application in era of large mainframes.
- Family and friends ridiculed idea.
- 50 Years later it has it been done ??

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What Research is & is NOT

Characteristics of Research.

Intensely personal activity
 Discovery of new knowledge
 Societal benefits
 Publication of discovery
 Creative in nature
 Don't know if it can be done
 Public activity & results

Characteristics of Projects.

Teamwork allowed
 Use of known knowledge
 Benefits aimed at sponsor
 Publication not necessary
 Derivative in nature
 Know it can be done ($P > .5$)
 Proprietary activity &

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What Research Is NOT

Characteristics of NOT Research

Loud Assertion w/o reference	Presentation of the Known
Argument by Authority	Anybody's Opinion
Fact without reference	Reference without vetting
Literature Search	Library "Research"

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Why We Do Research

- 1. Discover new knowledge**
- 2. Solve meaningful problems**
- 3. Answer questions worth knowing the answers to**
- 4. Fulfill a vision**
- 5. May be useful**

- Lipman Bers' quote
- Eugene Wigner's quote
- Albert Einstein's Razor

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Lipman Bers' quote

[Personal Communication]

“There is an infinite number of true theorems. Work only on important ones.”

[Work on what looks like it will be “useful” elsewhere.]

Eugene Wigner's quote

“The unreasonable effectiveness of mathematics.”

[Any mathematics is probably eventually useful.]

Albert Einstein's Razor

Let beauty lead you.

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4 Research Examples

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4 Research Examples.

A. Three of these are NOT DPS-like

1. They are Mathematical/Physical in nature
2. DPS-like is often not mathematical but could involve some basic statistics or optimization

B. The fourth is DPS-like but not specific

C. The commonality is the difficulty defining the problem and finding the solution [50/50]

D. You will be getting more DPS-like examples below (2) and in the future in this Research course

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4 Research Examples.

1. de Broglie's Paragraph [Notice it in Nature]
2. My "Why IS That?" [Notice it in Form]
3. Malcolm Cohen – Navy/Civilian – A4 Crashes
Physiological Psychologist (Assigned by the
Navy) "Applied Research",
[Notice it in the Real Physical World]
4. Web Services &/or XML Languages, "Applied
Research", often for application integration
[Notice it in Current Technology]

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4 Research Examples.

But First A Reminder To Critics

Das Ei Des Columbus - The Egg of Columbus

[I learned it in a Scientific German Course]

1. Columbus Returns & Reports
2. Committee of Great Men Reviews Results
3. "Trivial and Obvious"
Go west and run into land – no big deal.
4. Columbus: "Make an egg stand on end."

**Notice the 18 years from 1905 to 1923
in the first example (de Broglie)**

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#1 de Broglie: One Paragraph Thesis

[Theoretical Physics]

Hey!
Get a
Nobel
Prize
for
seeing
a
weird
thing:
 $E = E$

(Translated from *Comptes rendus*, Vol. 177, **1923**, pp. 507-510)

Let us consider a material moving object of rest mass m_0 moving with respect to a fixed observer with a speed $v = \beta c$ ($\beta < 1$). According to the principle of the inertia of energy, it should possess an internal energy equal to $m_0 c^2$. On the other hand, the quantum principle suggests associating this internal energy with a simple periodic phenomenon of frequency ν_0 such that

$$h\nu_0 = m_0 c^2$$

c being, as usual, the limiting velocity of the theory of relativity and h Planck's constant.

Lousy
notation,
uses
 v
for
velocity
and
 ν_0
frequency
!

This is the wave nature of matter (has a frequency!)

$E = h\nu_0$ [photoelectric effect] and $E = m_0 c^2$ [relativity]

Einstein's Nobel Prize \uparrow . *Both are by Einstein! in 1905.*

Schrödinger did Wave Equation in 1925

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Prince Louis de Broglie

1. He added some more analysis of what is the particle's wave frequency
2. He analyzed a light particle (slightly incorrectly) using basic relativity
3. He analyzed an electron in a circular orbit and showed the same results as Bohr & Sommerfeld (the Old Quantum Theory) and said he had derived optics of particles elsewhere – which he did
4. All in 4 pages [*basic idea in 1st paragraph*]

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RADIATION — *Waves and Quanta*¹Note of **Louis de Broglie**, presented by Jean Perrin.(Translated from *Comptes rendus*, Vol. 177, 1923, pp. 507-510)

Let us consider a material moving object of rest mass m_0 moving with respect to a fixed observer with a speed $v = \beta c$ ($\beta < 1$). According to the principle of the inertia of energy, it should possess an internal energy equal to $m_0 c^2$. On the other hand, the quantum principle suggests associating this internal energy with a simple periodic phenomenon of frequency ν_0 such that

$$h \nu_0 = m_0 c^2.$$

c being, as usual, the limiting velocity of the theory of relativity and h Planck's constant.

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Prince Louis de Broglie

1. He was **prepared** in QM & Relativity
2. He was free to be “stupid – clever”
3. It took Einstein's intervention to get him his degree (faculty of Great Men thought it was nonsense)
4. It took years until experiment proved him right (electron optics).
5. His article 1923; Schrödinger's Wave Equation 1925; his Nobel Prize 1929

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#2 RIF (Me) [No Nobel Prize]

[Theoretical Computer Science]

I noticed a strange relationship for the N-D cube array of length n. [I have ABD in Math - NYU]

N-D Array of Length n

$$T_n^N \square n^N = ([n-1] + 1)^N =$$

Cell Count

Binomial Expansion

$$\sum_{i=0}^N \binom{N}{i} (n-1)^i (1)^{N-i} \square \sum_{i=0}^N \binom{N}{i} T_{n-1}^i$$

Sum of Smaller Arrays of all dimensions 0 to N

This relates arrays to the binomial theorem.

This is a new geometric truth about array decompositions.

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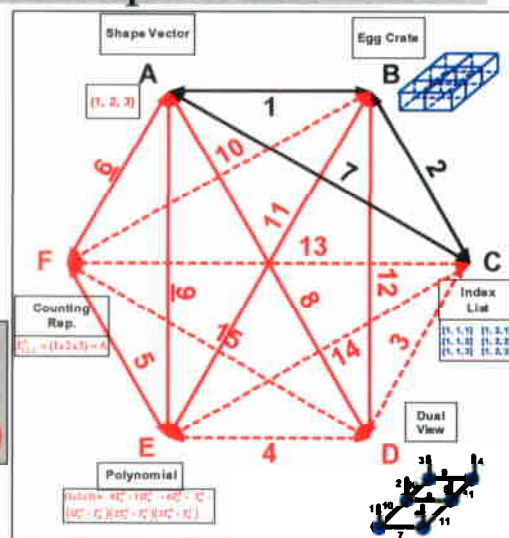
ERA / NERA Representations

RED is new is mine.

Holds for NERAs too

$$T_{1,2,3}^3 = (1 \times 2 \times 3) = 6$$

$$(1 \times 2 \times 3) \approx 6T_0^0 + 11T_0^1 + 6T_0^2 + T_0^3 = (1T_0^0 + T_0^1)(2T_0^0 + T_0^1)(3T_0^0 + T_0^1)$$



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THE MASTER EQUATION
(Example)

2x3x4 Full Decomposition to Null Arrays

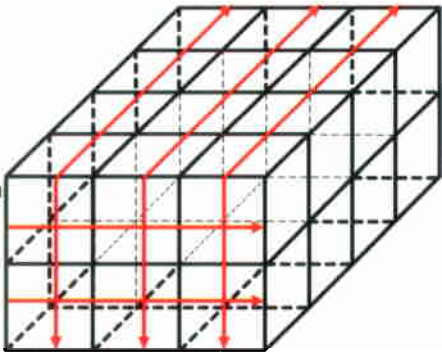
There are 24 scalar cells. [0-D]

There are 26 vectors: [1-D]
6 vectors front to back
12 vectors top to bottom
8 vectors right to left

There are 9 matrices (planes): [2-D]
2 horizontal planes top to bottom
3 vertical planes left to right
4 vertical planes front to back

There is one 3-D Entity. [3-D]

There are no higher D Entities. [4....D]



$$T_{(2,3,4)}^3 = T_0^0(24) + T_0^1(26) + T_0^2(9) + T_0^3(1)$$

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RIF: A Good Topic Should Be Rich in Further Questions

1. What if **N** is negative or complex?
2. What if **n** is negative or complex?
3. Master equation allows subtraction of arrays - what's this mean? **Annihilation!**
4. Generalization to ragged arrays?
5. What about arrays of arrays [= set theory]?
6. What about n-continuous arrays and quantum computing? **[Master equation does hold!]**

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RIF: Work on what you know & like

0. I worked in APL development on and off for over 8 years.
1. I worked on this problem on and off for 10 other years.
2. I generalized it to N-D Bricks.
3. I found a master equation in null arrays (by recursion).
4. I developed an explicit algorithm for all sub arrays' cells.
5. I developed code in APL, C++, and Java.
6. I found potential applications in Hyper cube machine architectures and data mining OLAP.

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#3 Malcolm Cohen – Problem

[Private Communication] [Applied Physiological Psychologist]

- Some A4s crash (randomly) for no apparent cause
- Catapult off carrier & go immediately into water

“Data”

- “Artificial Horizon” gauge problem was fixed
[Therefore not the gauge]

Survey Data

- Artificial Horizon gauge not trusted
- Crashes only on moonless nights

[Therefore no visual cues]

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Malcolm Cohen's – Theory*

[Personal Communication]

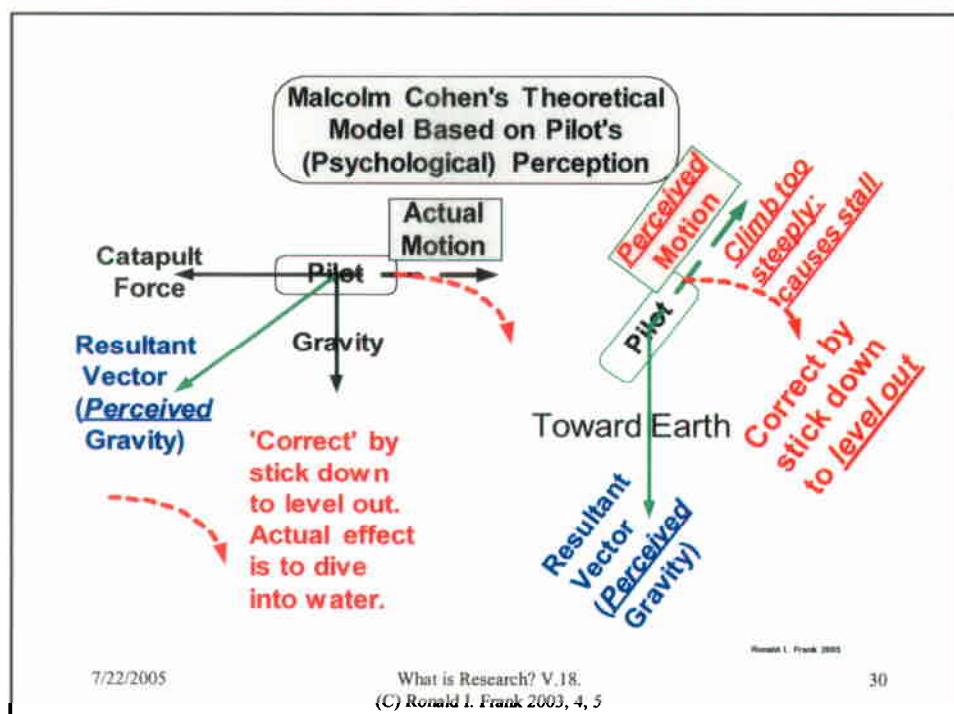
- Douglas Skyhawk – (A4) has noted reliability
- Pilots can't see outside and don't trust gauge
- **Some perception causes stick forward into water**
- **It has to be a positional perception miscue**

* Cohen, M. M., Crosbie, R. J. & Blackburn, L. H.
Disorienting effects of aircraft catapult launchings. *Aerospace Medicine*, 1973, 44:37-39.

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Malcolm Cohen's - Solution

- **Train pilots** to understand incorrect perception
- **Train pilots** to trust artificial horizon gauge

Result

- **No more crashes due to this cause**

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#4 Web Services &/or XML Languages

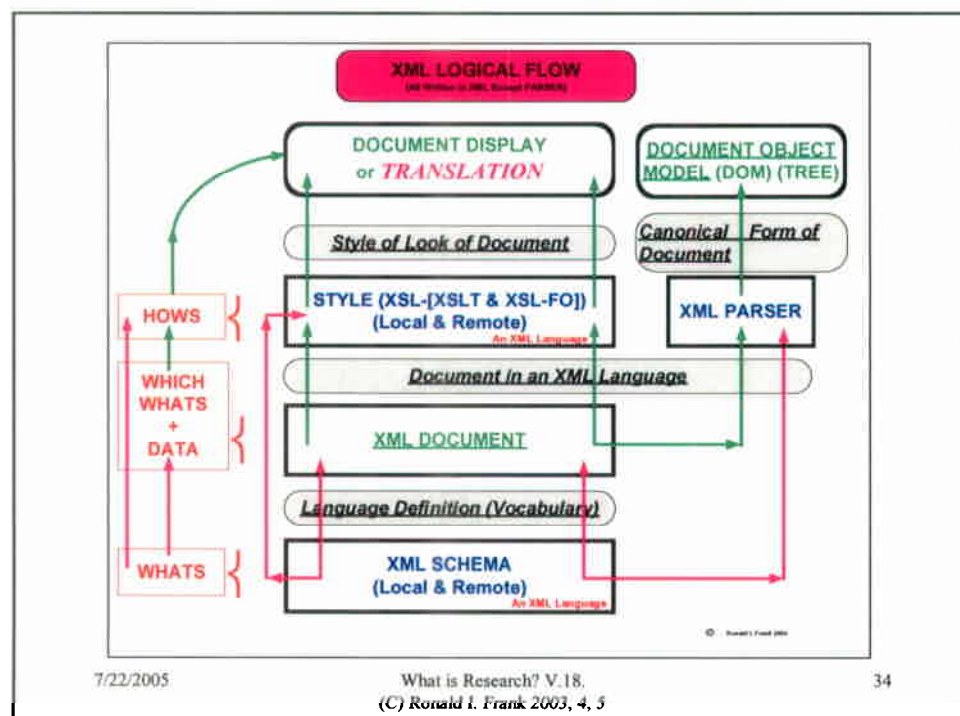
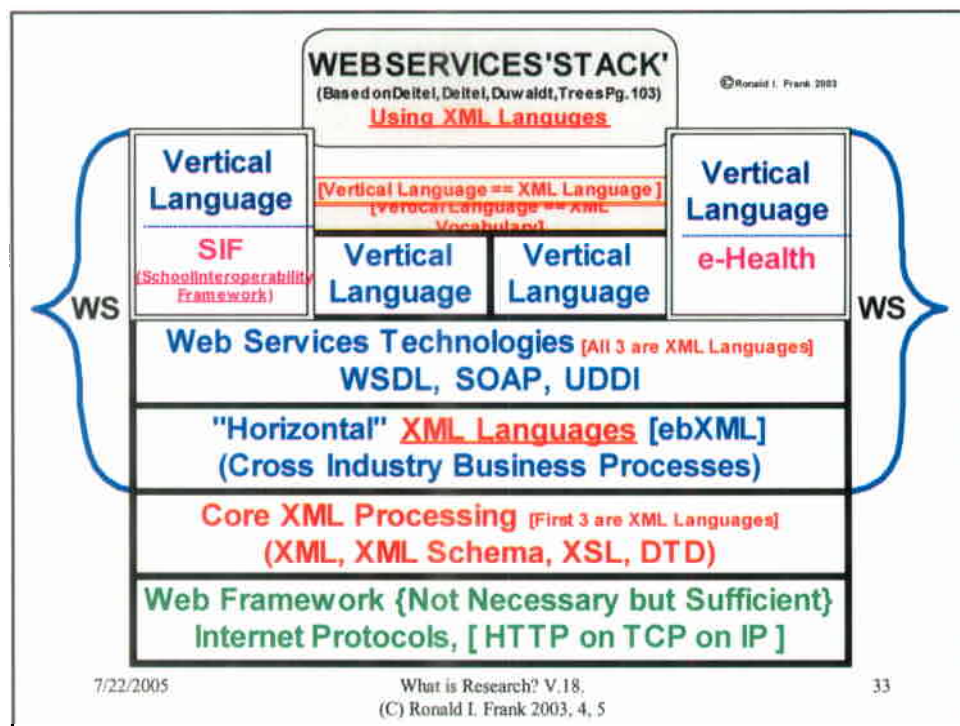
(NO LONGER Conjectural) [Applied Information Systems]

1. XML based.
2. Standards based.
3. "Applications" require defining general languages for new uses
[language architecture == vocabulary].
4. Requires understanding of an application domain. Often used for app integration.
5. Limited window of opportunity for dissertation level work [2-3 years?].

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2 Current Dissertations

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#1 Product Costing Framework

Best price subassemblies

1. WS / XML based – Industry Integration.
2. Standards based – some not yet in place
3. Needs many specific languages – some exist
4. Small restaurants as a real example
5. Dozens of DFDs and Use Case Diagrams
6. Very intricate NEW/USEFUL architecture
7. Literature search was global (UN a player)

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#2 SARBOX Compliance Architecture

Enterprise Accounting / Auditing Integration

- 1. WS / XML based – Enterprise Integration.**
- 2. Standards based – one new one**
- 3. Needs one or two specific languages**
- 4. Accounting Standards as a real driver**
- 5. ~4/Ea. DFDs and Use Case Diagrams**
- 6. Straight forward architecture**
- 7. Literature search was US only**
- 8. Virtual close is a side effect**

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Commentary & Advice

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**IT'S BEST TO WORK IN
AN AREA YOU ALREADY
KNOW AND LIKE
OR
WILL HAVE FUN
LEARNING**

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**Plan for reading / learning
equivalent to 9 graduate
credits (in one year)**

**Literature search is NOT
Research!**

Research is CREATIVE!

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HAVE FUN OR YOU PROBABLY WON'T FINISH

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Have a Vision

- **It does not exist (show this)**
- **It can exist (argue this)**
- **It should exist (argue this)**
- **Make it exist (do this)**
- **Feasibility is enough**

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Prepare for Failures and False Starts Along the Way

- **Cape Canaveral, was Cape Kennedy**
- **was Cape Canaveral**
- **which was called “Cape Carnival”**

**Because of all of the early
spectacular failures.**

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**A GOOD TOPIC SHOULD
BE RICH IN FURTHER
QUESTIONS**

SO

**YOU CAN CONTINUE
PUBLISHING**

IF YOU WANT TO

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**You don't "get an idea"
and just start writing.**

**You start writing and
get ideas!**

[RIF 2004,5]

**Your real problem is to
find how you can create
added value by solving a
problem.**

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**Being able to state
a topic or an idea
does not mean that you
know what
you are talking about
- or better -
that you are talking about
what you know.**

[RIF 2003]

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About Dissertation Questions / Problems

1. Finding them is $\frac{1}{2}$ the effort

But more than $\frac{1}{2}$ the emotional pain

2. The answer is $\frac{1}{2}$ the effort

But more than $\frac{1}{2}$ the fun

3. Writing and production is $\frac{1}{2}$ the effort

But most of the real pain

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Previous Questions / Problems

1. Where do babies come from?

2. Where does blood come from?

3. What are stars?

4. Why are stars?

• **25 WHYs and you get to GOD**

5. Why is the sky blue?

6. How can legacy systems be turned into a Web Service?

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Einstein: About Research

**“If we knew what it was we are doing,
it would not be called research.” ***

Quoted in *Scientific American* September 2002 Vol. 287 No. 3 (a special issue on Time) in the Antigravity column by Steve Mirsky.: “Einstein’s Hot Time” pg. 152.

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Process & Proposal Sample

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Doing a dissertation is itself a project: apply your project management skills.

This should be a SMALL, but ongoing effort!

- Lay out a Gantt chart (back of the envelope)
- Do a work breakdown structure
- Constantly monitor actual against baseline
- Do an earned value analysis
 - (value added vs time spent)

This should be a SMALL, but ongoing effort!

- Don't estimate your time to completion based on your writing schedule.
- Research time has to be factored in.

This should be a SMALL, but ongoing effort!

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**Writing about your own contribution is
not a matter of just describing an idea.**

**It is a matter of proving it or showing
how to do it.**

Ideas are ~\$0.10/dozen.

**Usefully articulated and proven ideas
are not common.**

Implemented ideas are rare.

Accepted ideas are extremely rare.

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It is up to YOU to find a problem.

It is up to YOU to convince your advisor and committee that it is worth doing and worth THEIR time.

It is up to YOU to convince your advisor and committee that it is done.

It is up to YOU to convince your advisor and committee it is worthy.

Drs. don't seek approval, they know & prove. Drs. don't "piss & moan", cry, yell, or try extortion.

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We are here to help – not to do.

If you can't find a problem, we will make suggestions, but you choose.

Learn from your advisors but don't worship them.

It is up to YOU to do the work.

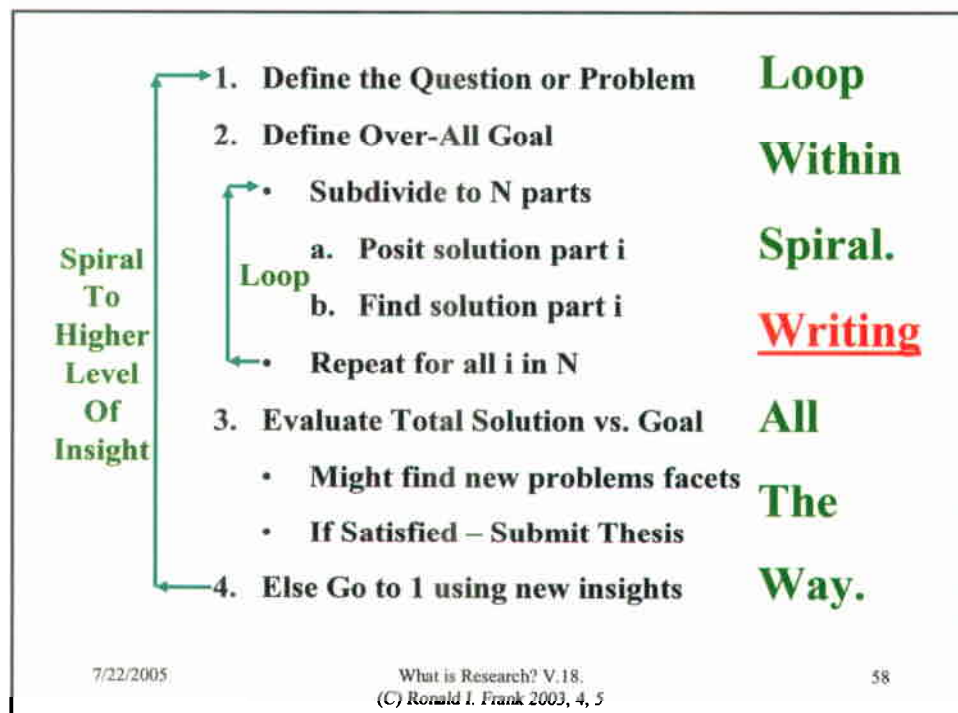
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It is up to YOU to <u>schedule</u>.
It is up to YOU <u>control the process</u>: i.e., initiate meetings, set goals, set criteria.
It is up to YOU to <u>find help</u> if needed.
It is up to YOU to recognize hand- waving bull.... from insightful analysis.
If you spent a lifetime being sloppy, we can't cure you. Repent oh you sinners!
<small>Drs. don't suck up, they don't have to. Drs. don't try to fake it, they boldly take large slips in schedule.</small>
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<p style="text-align: center;"><u>Warning About</u> <u>"DATA"</u></p> <p style="text-align: center;"><u>Many uses mean SURVEY DATA</u></p> <ol style="list-style-type: none"> 1. A few DPS dissertations use surveys 2. Most DPS dissertations do not 3. "DATA" might mean relevant examples 4. "DATA" might mean similar systems 5. "DATA" might mean previous work 6. "DATA" might mean environmental vars <p><small>7/22/2005 What is Research? V.18. 56 (C) Ronald I. Frank 2003, 4, 5</small></p>



Notice that this is very like iterative refinement in software development.

Beware the **ANXIETY BLOCK** in getting started. Just write something to start and “Plan to Throw One Away” as Brooks says in Chapter 11, MMM.

JUST DO IT.

Do something, anything – it doesn't matter. Don't think, do. Once started, correct your mistakes.

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Once Started:

Beware **AVOIDANCE BEHAVIOR**

Procrastination is well known. **BUT**
Substitution is more insidious:
There are always more important or
more pressing activities to substitute
for your dissertation work.

JUST DO IT.

A little bit of continuous progress doesn't interfere with life. YOUR life includes your dissertation.

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Proposal Outline [Not Unique][Short]

1. The **Problem** and its context [== Literature Search]
 - 1.1 Statement of the problem
 - 1.1.1 List of sub problems
 - 1.2 Problem context [Include USE CASES / DFDs]
 - 1.3 Limitations of scope
 - 1.4 Definition of terminology
 - 1.5 Importance of the work
 - 1.6 The relevant literature and **background** [see 4 below]
- 2 Proposed **Solution** (components and schedule)
 - 2.1 Solution description [== Your "value add"]
 - 2.2 Methodology and Work Breakdown Structure
 - 2.2.1 Repeat for each sub problem
 - 2.3 Initial schedule [Baseline for **planning & monitoring**]
- 3 The **Researcher** [YOU] (qualifications and background)
 - 3.1 What preparation does researcher already have
 - 3.2 What new knowledge or skills **are required**
- 4 Bibliography [Reference **EVERY** assertion you made]
- 5 Appendixes (supporting peripheral detail)

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I. Bernard Cohen: About Your Dissertation

[He Had Many Many Dissertation Students]

[Science and Mathematics Historian]

[First American Doctorate in the History of Science]

"Don't get it perfect; get it done." *

*
Quoted in a memorial article by one of his students: "I. Bernard Cohen (1914-2003)" By Judith V. Gabiner in the MAA Focus
Vol. 23 # 6, August/September 2003 pg. 24.

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Production of a Thesis

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Production of Text 1/2

1. **BUY Strunk & White, (& Chicago Manual of Style), a good NEW Dictionary, and a good NEW Thesaurus (CD version is OK, even better)**
2. **Get your tools early, learn, and use them all along.**
 - **Word and PowerPoint {the Pace Dissertation Format}**
 - **Endnote (bibliography) {the Pace Dissertation Format}**
 - **Visio (DFDs, Use Cases, UML, ERDs)**
 - **PIM (for scheduling meetings and To Do's)**
 - **Browser**
 - **Acrobat WRITER (for mandatory final version)**
 - **H/S Data Connection (comm to committee & libraries)**
 - **.NET/C#/Java/XML/VB [if implementing] [MSDNAA]**

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Production of Text 2/2

1. Have a really good machine, OS, software, and printer set up BEFORE you start. **Keep it stable.**
 - ***YOU and only YOU own, control, and use it.***
2. Backup often ALL files (set of 3 generation sets).
 - Keep at least one set off-site, best is 2
3. Get a BIG Thumb drive for moving copies to Pace
4. Try out 24 lb. bond on your printer early
 - **Many cheaper printers can't hack it**
5. Learn how to change ink & fix jams

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Production of Final Artifact

1. Be prepared to print a lot
 - Electronic files don't get read
2. The final hand-in can take weeks
 - **AFTER you are done.**
3. **The mandatory PDF of a your large .doc with many diagrams, figures, and other imbeds can take an hour + to run – don't cut it off. [It can crash.]**

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Appendix 1 Research Paper Outline

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Research Paper Outline 1/4

(For Reporting On Someone Else's Paper OR For Your Own)

1. Header
 - Topic
 - Title
 - Author(s)/Institution
2. Executive Introduction
 - "Tell 'em what you're going to tell 'em"
 - What will be the central contribution
 - Where does this fit into the Universe (context)?
3. Problem Statement
 - "Tell 'em"
 - Use Cases

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Research Paper Outline 2/4

4. Current State of the Art/Science/Business
 - "Tell 'em"
5. Solution to Stated Problem
 - "Tell 'em"
 - What is the central contribution
 - Use Case
6. Methods Employed in Solution
 - "Tell 'em"
7. Results & Conclusion
 - "Tell 'em"

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Research Paper Outline 3/4

8. Future Direction
 - "Tell 'em"
9. Summary
 - "Tell 'em what you told 'em"
 - What was the central contribution
10. References
 - A. Every major statement or assertion needs proof or reference
 1. Peer reviewed journals
 2. Textbooks & Theses (especially recent versions)
 3. May use URLs but with land based source addresses
[Indicate date YOU last accessed it]
 - B. Your opinion must be clearly delineated as such and is weak

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Research Paper Outline 4/4

10. References (cont.)

- C. Your assertion without proof is useless and not accepted
- D. Commercial products and consultancies are weak to useless
 - Except for proof of current state of the Business

11. Appendices

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Appendix 2

Maintain a Developer's Notebook

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Date: October 28, 2005
From: Prof. Frank
To: DPS Research Seminar
Subject: Maintain a Dissertation Notebook
Reference: The Real World [Don't do this & look foolish]

Buy A Bound (NO METAL SPIRALS) Computation or Lab Notebook [~\$12.00] that has a left margin set off, quadrille paper, and pagination.

THIS is THE ONLY PLACE ON EARTH THAT YOU WRITE, DIAGRAM, OR DOODLE ABOUT YOUR Dissertation.

This is not a class notebook. It is not a personal diary. It is not used for ANYTHING else. It is not your dissertation, only a place to put ideas, thoughts and data.

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Every page is sequentially numbered. Each new topic or coding project starts with a line across the whole page and a date in the left margin with a short descriptive name in the margin or at top. Never remove pages!!!

You can make margin notes to keep track of the structure of the notes. For example, use circles & dates for TO-DO items. Cross them out when they are completed. If you need to, you can generate an index of topics and dates on the last few pages as you go along. This helps if you are jumping topics a lot.

Advisor and other meeting notes go in here, as do phone notes & #s and IDs of colleagues. No page-width line is put in until the start of the next topic. Interpolated sections from other topics are marked by a vertical mark in the margin, a blank area, and the name of the topic.

Paper is cheap.

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You can scotch tape in small listings, or other documents from outside sources. There should be no other paper you use to write on - ever. Only IMPORTANT email (decision agreements) get pasted in. Write under your paste-ins what they are incase they fall out.

Put your name, advisor's name, start date and leave a space for end date on the front outside. [You may generate more than one notebook.]

Put your address, phone number and email ID on the inside front cover so that when you lose it, the finder can contact you for pickup. Near your info, put a polite request to the finder to return your notebook - it can help. Label the book "Personal and Confidential" just to emphasize how you view it. Offer a small reward for its return.

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If you have a patentable idea, document it in great detail with tutorial comments and immediately get (or leave space for quickly getting) two colleagues to read and UNDERSTAND the idea.

Then have them write, sign, and date a statement that they have read the idea and have understood it.

This is why the book must be bound, every page numbered, and every item dated - so that there can be no question about the idea pages being inserted at a later date.

You too can win a patent law suit for billions of dollars [lasers] based solely on this kind of documentation of a good idea.

All pocket-recorded daily notes get put in THAT NIGHT if not immediately.

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Appendix 3

The Rest of the de Broglie Paper

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For the fixed observer, the frequency $\nu = \frac{m_0 c^2}{h \sqrt{1-\beta^2}}$ corresponds to the total energy

of the moving object. But, if this fixed observer observes the internal periodic phenomenon of the moving object, he will see it slowed down and will attribute to it a frequency $\nu_i = \nu_0 \sqrt{1-\beta^2}$; for him this phenomenon varies therefore like

$$\sin 2\pi \nu_i t.$$

Now let us suppose that at the time $t = 0$ the moving object coincides in space with a wave of frequency ν defined above and propagating in the same direction as it does with the speed $\frac{c}{\beta}$. This wave, which has a speed greater than c , cannot correspond to

¹ Concerning the present note, see Brillouin, *Comptes rendus*, Vol. 168, 1919, p. 1318.

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transport of energy; we will only consider it as a fictitious wave associated with the motion of the object.

I maintain that, if at the time $t = 0$, there is phase agreement between the vectors of the wave and the internal phenomenon of the object, this phase agreement will be maintained. In effect, at time t the object is at a distance from the origin equal to $vt = x$; its internal motion is then represented by $\sin 2\pi v_1 \frac{t}{\nu}$.

The wave, at this point, is represented by

$$\sin 2\pi v \left(t - \frac{x\beta}{c} \right) = \sin 2\pi v x \left(\frac{1}{v} - \frac{\beta}{c} \right).$$

The two sines are equal and the phase agreement is realized if one has

$$v_1 = v(1 - \beta^2).$$

a condition that is clearly satisfied by the definitions of v and v_1 .

The demonstration of this important result rests uniquely on the principle of special relativity and on the correctness of the quantum relationship as much for the fixed observer as for the moving observer.

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Let us apply this to an atom of light. I showed elsewhere² that the atom of light should be considered as a moving object of a very small mass ($< 10^{-39}$ g) that moves with a speed very nearly equal to c (although slightly less). We come therefore to the following conclusion: *The atom of light, which is equivalent by reason of its total energy to a radiation of frequency ν , is the seat of an internal periodic phenomenon that, seen by the fixed observer, has at each point of space the same phase as a wave of frequency ν propagating in the same direction with a speed very nearly equal (although very slightly greater) to the constant called the speed of light.*

² See *Journal de Physique*, 6-th series, Vol. 3, 1922, p. 422.

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Let us consider now the case of an electron describing a closed trajectory with uniform speed slightly less than c . At time $t = 0$, the object is at point O . The associated fictitious wave, launched from the point O and describing the entire trajectory with the speed $\frac{c}{\beta}$, catches up with the electron at time τ at a point O' such that $\overline{OO'} = \beta c \tau$.

One has then that

$$\tau = \frac{\beta}{c} [\beta c (\tau - T_r)] \quad \text{or} \quad \tau = \frac{\beta^2}{1 - \beta^2} T_r,$$

where T_r is the period of revolution of the electron in its orbit. The internal phase of the electron, when the electron goes from O to O' , has a variation of

$$2\pi \nu \tau = 2\pi \frac{m_0 c^2}{h} T_r \frac{\beta^2}{1 - \beta^2}.$$

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It is *almost necessary* to suppose that the trajectory of the electron will be stable *only if* the fictitious wave passing O' catches up with the electron in **phase** with it: the wave of frequency ν and speed $\frac{c}{\beta}$ has to be in resonance over the length of the trajectory. This leads to the condition

$$\frac{m_0 \beta^2 c^2}{1 - \beta^2} T_r = n h, \quad n \text{ being integer.}$$

Let us show that this stability condition happens to be that of the Bohr and Sommerfeld theories for a trajectory described by a constant speed. Let us call p_x, p_y, p_z the momenta of the electron along three rectangular axes. The general condition for stability formulated by Einstein is in effect

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$$\int_0^{T_1} (p_x dx + p_y dy + p_z dz) = nh \quad (n \text{ integer})^3$$

which, in the present case, can be written

$$\int_0^{T_1} \frac{m_0}{\sqrt{1-\beta^2}} (v_x^2 + v_y^2 + v_z^2) dt = \frac{m_0 \beta^2 c^2}{\sqrt{1-\beta^2}} T_1 = nh.$$

as above.

In the case of an electron turning in a circular orbit of radius R with an angular velocity ω , one finds again for sufficiently small speeds the original formula of Bohr:

$$m_0 \omega R^2 = n \frac{h}{2\pi}.$$

If the speed varies along the length of the trajectory, one finds again the Bohr-Einstein formula if β is small. If β assumes large values, the question becomes more complicated and necessitates a special examination.

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Pursuing research along these lines we have reached important results, which will be communicated soon. We are as of today able to explain the phenomena of diffraction and of interference taking into account the quantization of light.

³ The case of quasi-periodic motion does not present any new difficulty. The necessity of satisfying the condition stated in the text for an infinity of pseudo-periods leads to the conditions of Sommerfeld.

Translated by Brigitte and Barton Lane and transcribed by Warren F. Davis, January, 1978.

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Appendix 4

NERA Master Equation

[Applied to the (2x3x4) Array]

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THE MASTER EQUATION (for general regular arrays)

$$(n_1 \times n_2 \times \cdots \times n_{N-1} \times n_N) \square T^N_{(n_1, n_2, n_3, \dots, n_{N-2}, n_{N-1}, n_N)} =$$

$$\sum_{j=0}^N T_0^j \left(\sum_{\substack{(N) \\ (j)}} \left[(n_{i_1}) \times (n_{i_2}) \times \cdots \times (n_{i_{N-j-1}}) \times (n_{i_{N-j}}) \right] \right)$$

Sum of Products of combinations of axis lengths
Combinations of axis lengths $\Sigma = N$

$$T^3_{(2, 3, 4)} = T_0^0 (24) + T_0^1 (26) + T_0^2 (9) + T_0^3 (1)$$

$$(24 = 2 \times 3 \times 4) \quad (26 = 2 \times 3 + 2 \times 4 + 3 \times 4) \quad (9 = 2 + 3 + 4)$$

$$\begin{pmatrix} 3 \\ 0 \end{pmatrix} = 1, \& C_3^3 \quad \begin{pmatrix} 3 \\ 1 \end{pmatrix} = 3, \& C_2^3 \quad \begin{pmatrix} 3 \\ 2 \end{pmatrix} = 3, \& C_1^3$$

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Appendix 5 Typical Dissertation Outline

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Dissertation Outline 1 / 6

1. Header
 - Topic
 - Title
 - Author(s)/Institution
 - Your Copyright Notice
 - Committee Signature Sheet
2. Abstract (<350 Words)
 - "Tell 'em what you're going to tell 'em"
 - What will be the central contribution
 - Key Words for indexing
3. Preface (Background of your work)
 - Acknowledgements

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Dissertation Outline 2 / 6

4. Table of Contents
5. List of Figures [One figure can be the list of trade marks used]
6. List of Tables
7. List of Most Important Equations (if needed)
8. Introduction
 - Problem Statement
"Tell 'em"
Use Cases
 - Flow of Development
Where you are going

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Dissertation Outline 3 / 6

- Methodology Overview
How you will get there
 - Review of previous work (outline only here)
9. Background Material (if needed)
 - To better understand the problem
 - More detail on the current state of the art (if needed)
 10. Solution to Stated Problem
 - "Tell 'em"
What is YOUR central contribution
Use Cases
 - Methods Employed in Solution

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Dissertation Outline 4 / 6

11. Results & Conclusion

- "Tell 'em"
- **So What (the importance of the results)**

12. Future Direction

- "Tell 'em"
- Future research items

13. Summary

- "Tell 'em what you told 'em"
- Again: what was the central contribution **and** its value
- Where to go from here

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Dissertation Outline 5 / 6

14. References

- A. Every major statement or assertion **needs** proof or reference
 1. Peer reviewed journals
 2. Textbooks & Theses (especially recent versions)
 3. May use URLs but with land based **source** addresses
[Indicate date YOU last accessed it]
- B. Your opinion must be clearly delineated **as** such and is weak
- C. Your assertion without proof is useless **and** not accepted
- D. Commercial products and consultancies **are** weak to useless
 - Except for proof of **current state of the Business**

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Dissertation Outline 6 / 6

15. Appendices

- A. Supporting material only if it is hard to get
- B. Proofs or other mathematical work incidental to main flow
- C. Incidental historical information (for cultural literacy)
- D. Code or worked examples if too big for main text flow
- E. Releases if you are using other's work
- F. List of the tools you used if they were unusual or if their output is central to your conclusions (it this latter case maybe it should be a Reference instead)

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**What is
Research?**

THE END

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