An Engineer’s Journey to Prosperity or Disaster?

Information → Knowledge → (uncertainty) → Products → Prosperity?

Wisdom

(analysis) → (optimization) → (management)

(uncertainty) (Ethics)

by Jeffrey Fong, NIST, May 15, 2009
• What is NIST and what do I do at NIST?
• What is engineering?
• What is exciting about engineering?
• What is the downside of engineering?
• What is the trade-off?

~3 minutes per topic, total 30 slides

Please send comments to:
301-975-8217 or fong@nist.gov

Date Prepared: May 08, 2009
What is NIST and what do I do at NIST?
NEWTON APPLE TREE

“SCIENCE HAS ITS TRADITIONS AS WELL AS ITS FRONTIERS”

This tree is a direct descendant of the original tree whose fruit gave inspirational impetus to Isaac Newton's theory of gravitational forces. It was nurtured by the U.S. Department of Agriculture and transplanted here on the grounds of the National Bureau of Standards April 1966.
Uncertainty Plug-Ins for Engineering & Sciences

Slide # 05

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FEM Model of a Side Airbag

FEM Model of WTC North Tower Resonance (Enlarged View)

FEM Model of Airplane Impact of a 6-story model building
Material property

One

led to three

in

A Conceptual Plot of Building Reserve Capacity vs. Time

Credits: J. Gross, NIST, 2006; J. T. Fong, NIST, 2009.
An Interesting Phenomenon of Resonance Frequency Discontinuity between Free and Forced Vibrations of a Cantilever Beam with a Sensor Tip:

Free vibration: First mode frequency \( f_1 \)  

equals 180.8 KHz

Forced vibration at 20 nm sensor tip deflection:  

First mode frequency \( f_1 \)  

equals 579.9 KHz

Sample surface during free vibration of Cantilever Beam

<table>
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<tr>
<th>A(X)</th>
<th>B(Y)</th>
<th>f1</th>
</tr>
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<tbody>
<tr>
<td>deflection</td>
<td></td>
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<tr>
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<td>20</td>
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<tr>
<td>2</td>
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<tr>
<td>6</td>
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</tbody>
</table>
What is engineering?

What we have today

What we like to have tomorrow

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Engineers are creative problem solvers.

Engineering is essential to our health, happiness, and safety.
Engineering Education for the 21st Century

Charles M. Vest
President, National Academy of Engineering

ASEE Annual Conference
Pittsburgh, PA
June 23, 2008
Today, in 2008, our concerns are:

• How to make the first year exciting,

• How to communicate what engineers actually do,

• How to develop an understanding of business processes, and

• How to get students to think about ethics and social responsibility.

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And to this we must add:

- Nano-Bio-Info
- Large Complex Systems
- An entire new life-science base
- Astounding computation and storage capabilities
- Globalization
- Innovation
- Leadership
- Teamwork across disciplines, fields, nations and cultures
- Entrepreneurship
- Product Development and Manufacturing
- Sustainable Development

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Oh, And Our Graduates Must Be Global Engineers

- Technically Adept
- Broadly Knowledgeable
- Innovative and Entrepreneurial
- Commercially Savvy
- Multilingual
- Culturally Aware
- Able to Understand World Markets
- Professionally Flexible and Mobile

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Engineering is about Systems

• From nanobiological devices

• To large scale infrastructure

• To the earth itself
And Engineering Systems include, interact with, and serve:

- People
- Economies
- Business
- Law
- Politics
- Culture …
What is important in Engineering Education

Making universities and engineering schools exciting, creative, adventurous, rigorous, demanding, and empowering environments is more important than specifying curricular details.

End of Charles Vest’s 2008 Talk at ASEE Conf., Pittsburgh, PA.
An Alternative Definition (Fong, 2007)*


Engineering is about making things in an “optimal” way, engineering is about making things in a “wise” way, and engineering is about making things in an “ethical” way.

![Diagram showing the relationship between Information, Knowledge, Products, and Prosperity with the roles of Analysis, Optimization, Management, and Ethics.](image-url)
What is exciting about engineering?

In this New Century

Engineering is Dynamic with Exciting Frontiers and Grand Challenges

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Engineering Grand Challenges
Announced Feb. 15, 2008 by NAS-NAE

- Make Solar Energy Economical
- Provide Energy from Fusion
- Develop Carbon Sequestration Methods
- Manage the Nitrogen Cycle
- Provide Access to Clean Water
- Engineer Better Medicines
- Advance Health Informatics
- Secure Cyberspace
- Prevent Nuclear Terror
- Restore and Improve Urban Infrastructure
- Reverse Engineer the Brain
- Enhance Virtual Reality
- Advance Personalized Learning
- Engineer the Tools of Scientific Discovery

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Engineering Grand Challenges

- Energy
- Environment
- Global Warming
- Sustainability

- Reducing Vulnerability to Human and Natural Threats

- Improve Medicine and Healthcare Delivery

- Expand and Enhance Human Capability And Joy

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Think about these Challenges

• Some are imperative for human survival.

• Some will make us more secure against natural and human threats.

• All will improve quality of life.

• Most are of global scale.
What is the downside of engineering?

On a global scale, the competition is . . . FIERCE!
First Engineering Degrees

Source: Science and Engineering Indicators 2006, National Science Foundation, Washington, DC

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With New Players — Where the Expertise is

Young Professional Workforce
(college grads up to 7 yr.)

China  India  U.S.

Source: Competitiveness Index 2007, Council on Competitiveness, Washington, DC

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With New Jobs

U.S. % Employment by Sector

*History and Projection*

Source: Stuart Feldman, IBM Research, Presentation at Carnegie-Mellon University, 29 June, 2005

We must reverse this trend to stay competitive!!!

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What is the trade-off?

1. The trade-off is a “personal” choice.
2. For me, I love “geometry” & “computing.”
3. I love “science” & “asking questions.”
4. I love “statistics” & “optimization.”
5. I love “design” & “construction.”
6. I love “making decisions” & “. . . People”
7. So I chose to work in Engineering (1955 - ).
8. I was the principal designer of an arch dam and a pump-storage hydroelectric power plant in Roanoke, Virginia (completed 1959).
An Engineer’s Journey to Prosperity
and a sense of satisfaction

Information → Knowledge → ( - - ) → Products → Prosperity
(analysis) ( - ------- - ) (optimization) (management)
(uncertainty)

Wisdom

( Ethics )

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An answer* to 2 questions by T. S. Eliot

*Fong, J. T., Lecture Notes, Drexel University Course MEM800, Jan. 2007.

Where is the knowledge we have lost in information?

Eliot, T. S., After Strange Gods, 1934

Answer: Information with rigorous “analysis” is knowledge.

Where is the wisdom we have lost in knowledge?

Eliot, T. S., ibid., 1934

(Fong, 2007)*: Knowledge with quantified “uncertainty” is … wisdom.
A song to sing and dance with

Experiment ! Make it your motto day and night.

Experiment , and it will lead you to the light.

The apple on the top of the tree Is never too high to achieve,

So take an example from Eve … Experiment !

Be curious, Though interfering friends may frown.
Get furious, At each attempt to hold you down.

If this advice you only employ

The future can offer you infinite joy … and

merriment … Experiment ! And you’ll see!