Lecture 1
Introduction to Engineering Skill

C.M. Pascual
Professor, CACE

Topic

1.1. What is Engineering?
1.2. Engineering Thinking
1.3. Problem solving strategies
1.4. Application of Engineering Experience
1.5. Failure - Design, Construction, Operation or Maintenance?
1.6 Attributes of the Engineer

You will be an Engineer!

- Throughout this topic, you will answer:
  - 1. What is the problem that we have?
  - 2. What can you find out about the problem?
  - 3. What ideas are there already out there that could help us solve the problem?
  - 4. How can you use those ideas to determine a solution?
  - 5. What would your design look like?
  - 6. Build and test it. Does your design work?
  - 7. Show others!
  - 8. Make it better!

What is Engineering?

- The Accreditation Board for Engineering and Technology (ABET) defines engineering:

"the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind."

What is Engineering?

- Engineering is a profession like medicine, law, etc. that aspires to high standards of conduct and recognizes its responsibility to the general public.

What is Engineering?

- What would the world be like without engineers?

- Look at the following comics and figure out what engineers do!


The WORLD WITHOUT ENGINEERS

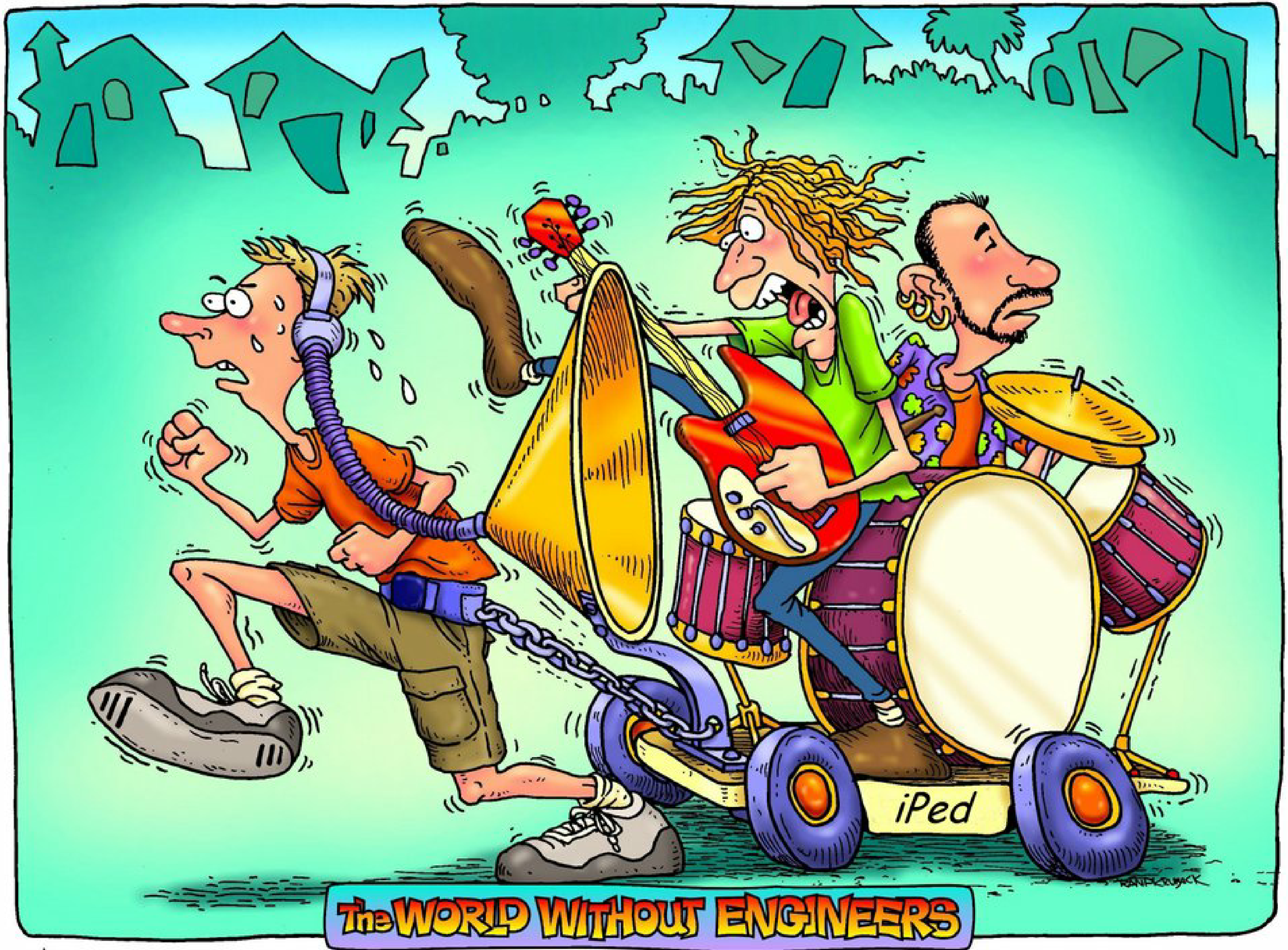
Agilent Technologies

http://www.agilent.com/find/edu


CONFERENCE CALL
LOBBY
OUTSIDE LINE
BOSS
COPY MACHINE
DATA LINK
The WORLD WITHOUT ENGINEERS

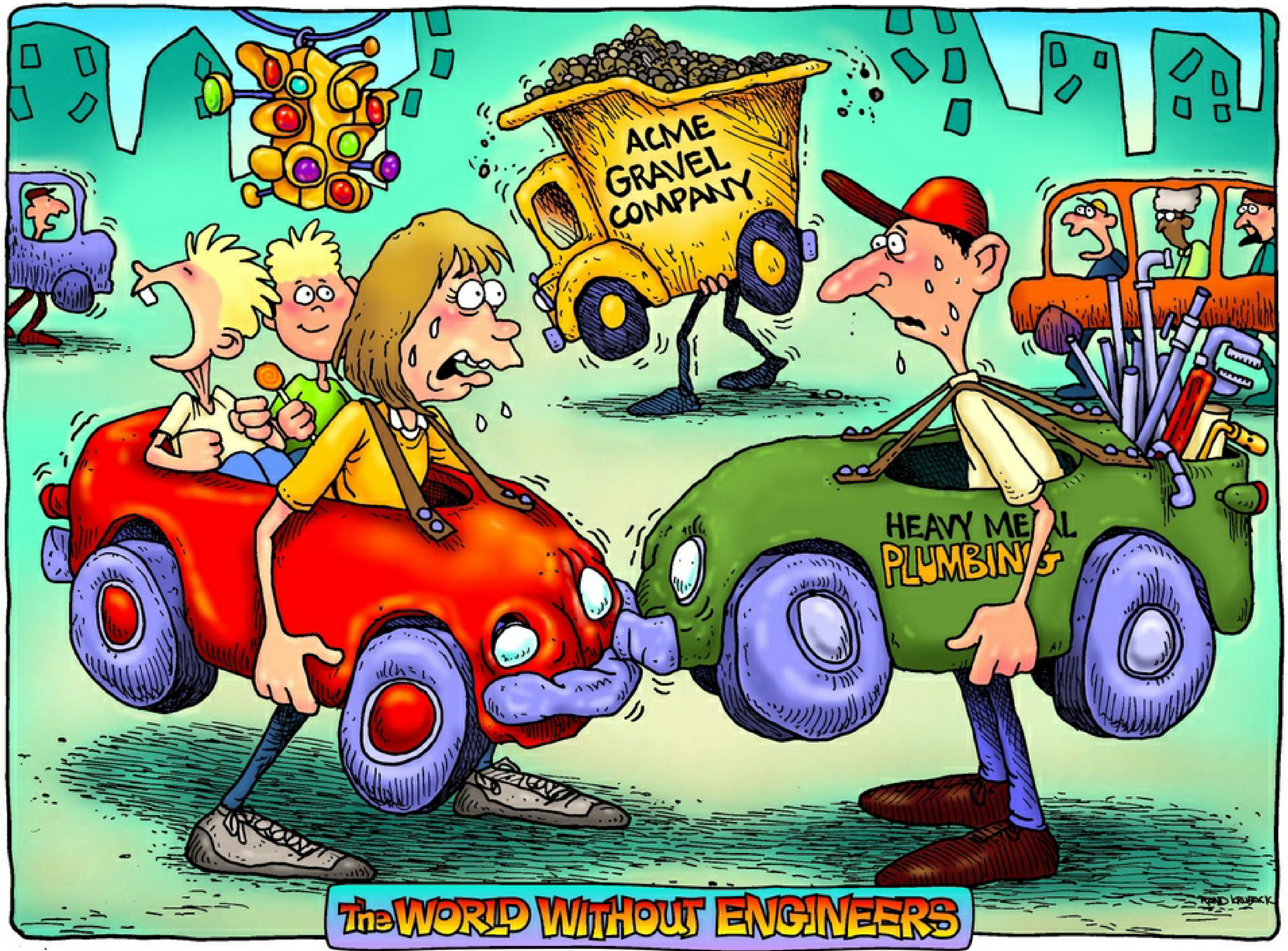
Agilent Technologies

http://www.agilent.com/find/edu



Agilent Technologies

http://www.agilent.com/find/edu



Agilent Technologies

http://www.agilent.com/find/edu

Agilent Technologies

http://www.agilent.com/find/edu

Engineers are Inventors!

- Engineers use science and math to solve real world problems!
- What are some of the types of engineers you've heard of?
- Possibly:
  - Agricultural, Aeronautics, Biomedical, Chemical, Civil, Electrical, Mechanical, Software, and Environmental. AND MANYMORE!

Look around you, virtually every manmade contraption you see was conceived of and created by an engineer!

Technology Team

- Scientist - Like an engineer, but a primary goal is the expansion of knowledge and understanding physical processes.
- Engineer - Applies knowledge of math and the physical sciences to the efficient design and construction of usable devices, structures and processes.

Technology Team

- Technologist - Technologists focus on direct application of established engineering principles and processes. Math, the physical sciences, and underlying engineering theory receive limited coverage. More interested in hardware and processes.

Technology Team

- Technician - Completes a 2 year degree in a narrow technical area such as electronics, drafting, or machining.
- Artisans - Training may be a combination of schooling and work experience. Examples include, welders, machinists, electricians, carpenters, painters, steel workers, and artists.

Engineering Disciplines

- Aerospace
- Agricultural
- Chemical
- Civil
  - Environmental
  - Ocean
- Computer Science and Computer Engineering

Engineering Disciplines

- Electrical and Computer Engineering
- Engineering Technology and Industrial Distribution
- Industrial
  - Biomedical
- Mechanical
- Nuclear and Radiological Health Safety
- Petroleum

Engineering Functions

The focus of an engineer's work typically falls into one or more of the following areas:

- Research - explore, discover and apply new principles
- Development - transform ideas or concepts into production processes
- Design - link the generation of ideas and the production

Engineering Functions

- Production and testing - manufacture and assemble components or products
- Sales - market engineering products
- Operations - maintain equipment and facilities
- Construction - prior to construction organizes bids, during construction supervises certain components of process

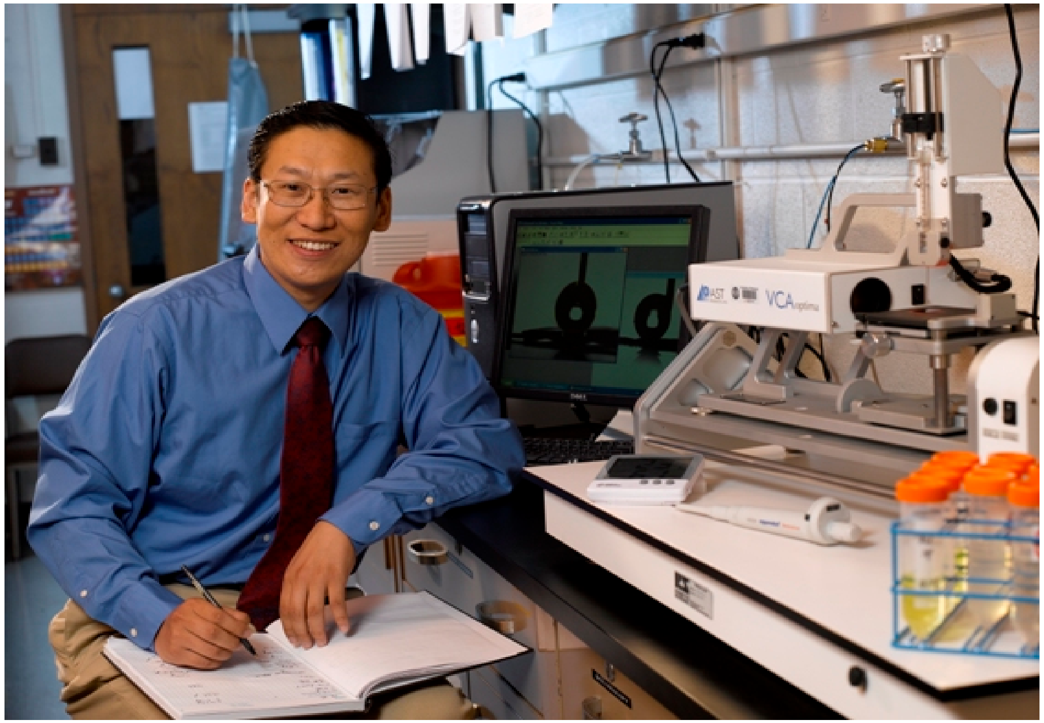
Engineering Functions

- Management - optimize the use of resources (equipment, labor, finances)
- Education - teach engineering principles in university and industrial settings
- Consulting - provide specialized engineering services the clients. May work alone or in partnership other engineers.

Now let's take a look at some real life engineers and what they're working on right now!

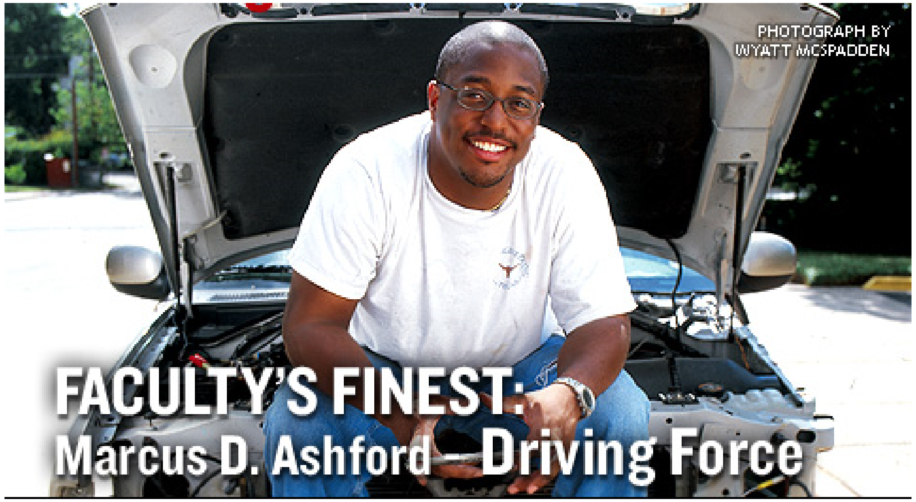
Separating Oil from Water

- Di Gao, a chemical engineer at the University of Pittsburg, invented a plastic-coated cotton material that could clean up the Gulf.



Designing Better Cars

- Marcus Ashford, a mechanical engineer at the University of Alabama, has invented a car engine with 80% less exhaust emissions.

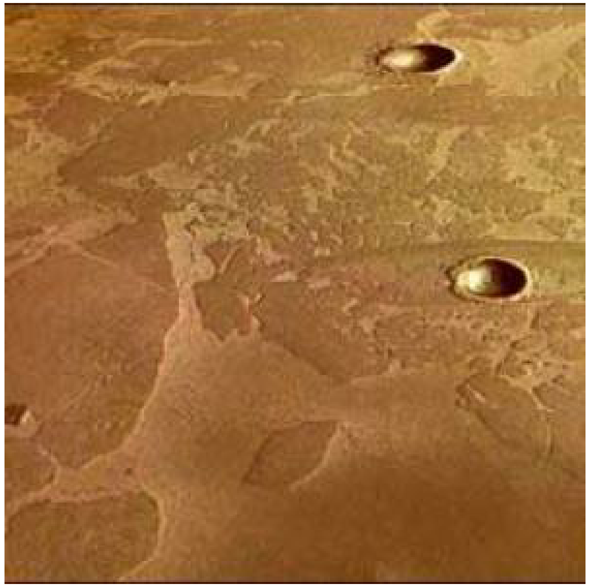


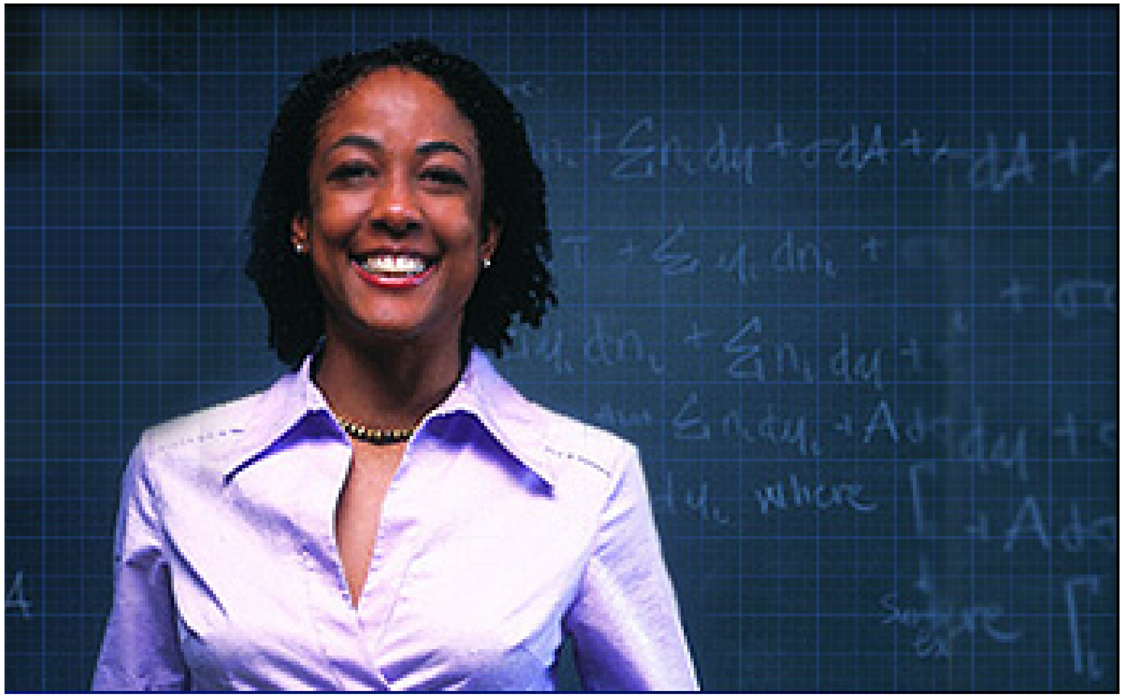
Cleaning Up the Ocean

- Alexandria Boehm is an environmental engineer who works on ways to clean up oceans near where people live.

Designing Space Colonies

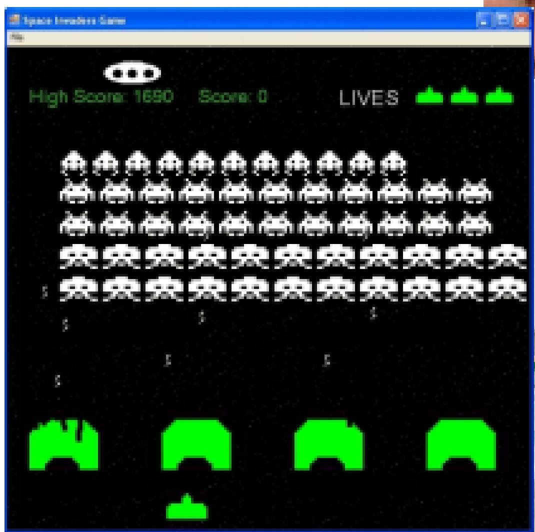
- Kimberly Jones is a civil engineer working on purifying water so that we can one day go to Mars!!!



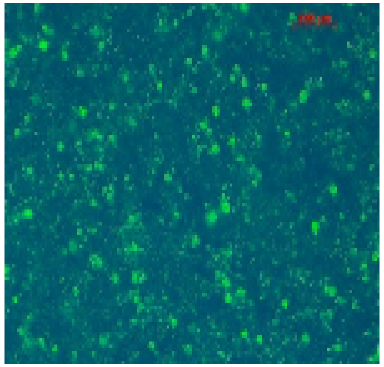


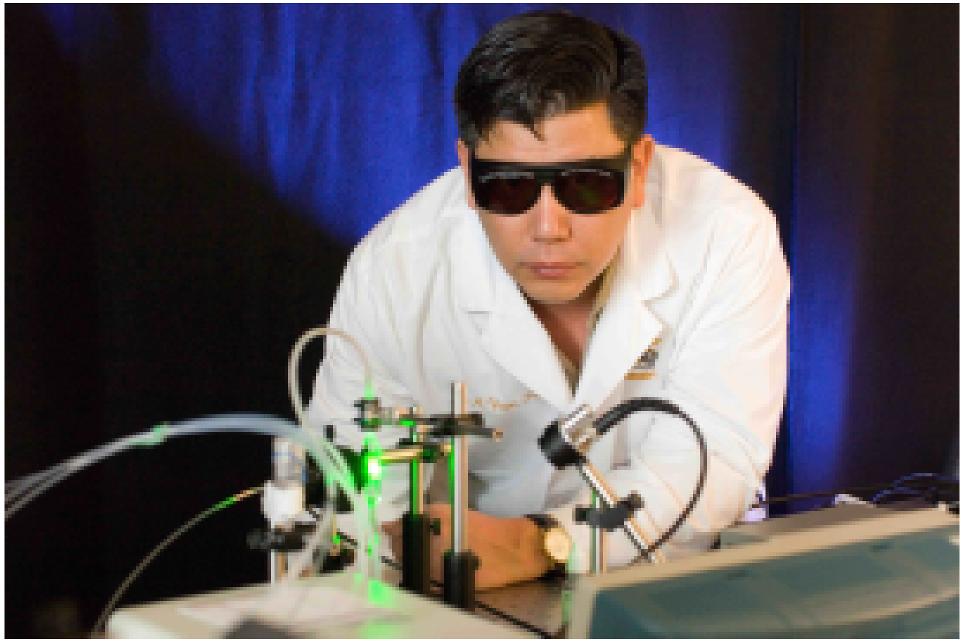
Controlling Computers with Thoughts

- Daniel Moran, a biomedical engineer at Washington University, has invented a way to play video games using only the human mind!



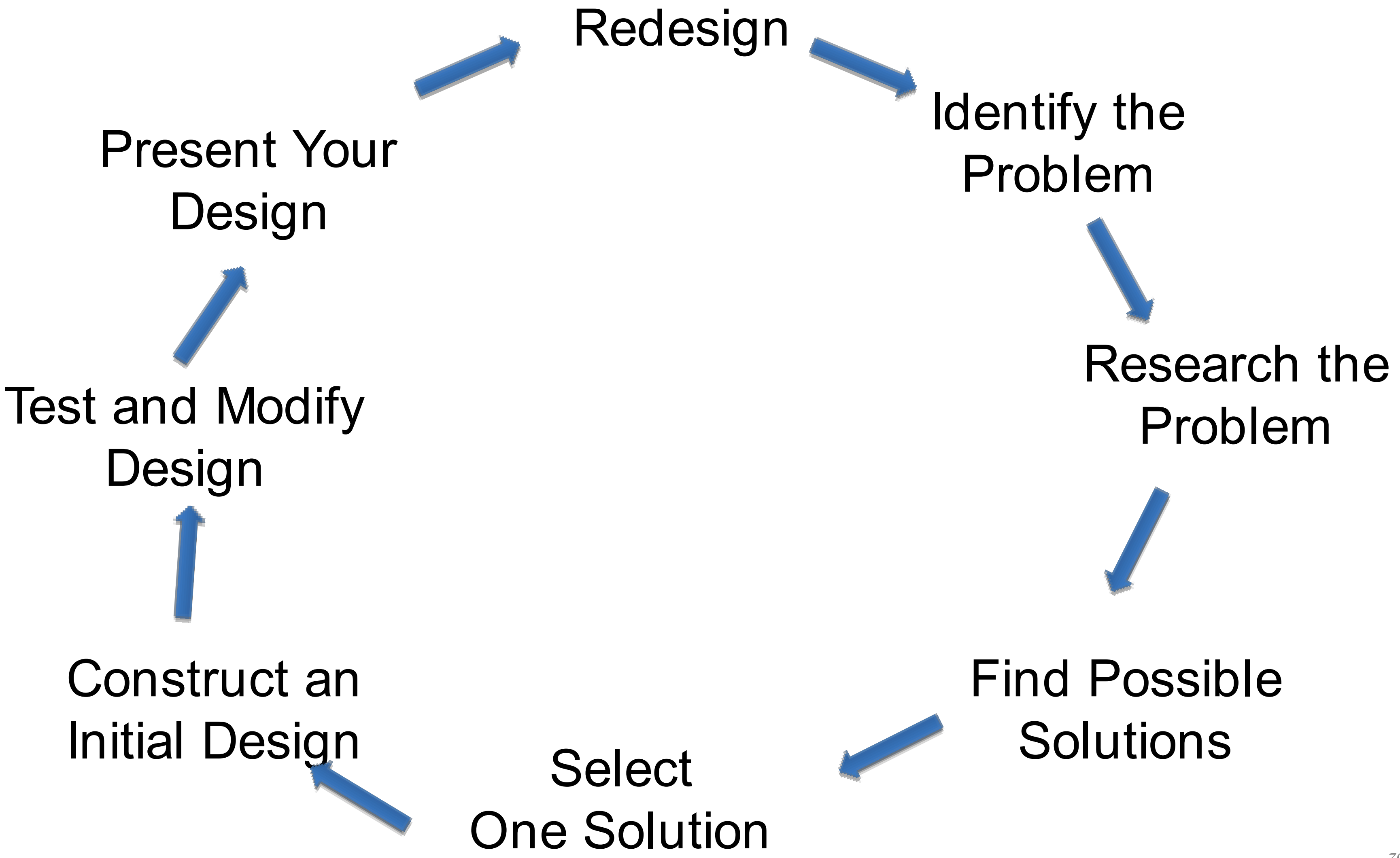
Listening for Cancer





- John Viator, a biological engineer, has invented a way to hear cancer cells.

The Engineering Design Process Loop



Assignment No. 1
(Submit next meeting)

1. Write a one page A4 size paper essay about yourself and what field of engineering you want to be. What specific problem in your environment you want to solve in the future?
2. Make a brief interview of a professional engineer you know and asked how he/she: (a) succeeded to study; (b) become an engineer; and (c) present job. Write your report on a one to two page A4 size paper.

Some learning video showing

10 Most paid eng'ng

Civil Eng'ng Intro

10 Tips for new eng'ng students

Watch, listen and learn.

Lecture 2
Engineering Career

C.M. Pascual
Professor, CACE

Topics

2.1. What does an Engineer do?

2.2. What types of Engineers are there?

2.3 How Does An Engineer Do Things?

Introduction

- Several characteristics of students that might have an interest in engineering are:
  1. Proficient skills in math and physical science
  2. An urging from a high school counselor
  3. Knows someone who is an engineer
  4. Knows that engineering offers literally dozens, if not hundreds of job opportunities
  5. Is aware that a degree in engineering is quite lucrative

Engineers and Scientists

- Scientists seek technical answers to understand natural phenomenon
- Engineers study technical problems with a practical application always in mind
- For example
  - "Scientists study atomic structure to understand the nature of matter; engineers study atomic structure to make smaller and faster microchips"

The Engineer and the Engineering Technologist

- Main difference between the two is:
  - Engineers design and manufacture machines and systems, while engineering technologists have the technical know-how to use and install the machines properly
- An example:
  - "The technologist identifies the equipment necessary to assemble a new CD player; the engineer designs said CD player"

2.1 What Do Engineers Do?

- Ways to get information about careers:
  - Visit job fairs
  - Attend seminars on campus by various employers
  - Contact faculty with knowledge of engineering fields
  - Get an intern or co-op position
  - Enroll in an engineering elective course

Engineering Degrees Awarded by Discipline (64, 946 degrees awarded) an Example

Who employs engineers?

Sector of Employment	Aero	Chem	Civil	Elec	Ind	Mech
Industry	63.3	74.0	48.9	69.6	76.7	75.8
Self	11.1	12.7	14.4	12.2	11.5	11.4
Education	3.5	5.0	3.0	4.9	3.6	3.9
Non-profit	2.4	1.7	0.5	1.5	1.7	1.1
Fed. Govt.	4.7	4.6	9.3	9.3	4.6	6.1
Military	4.3	0.3	1.3	0.9	0.3	0.4
Other Govt.	0.4	1.3	22.1	1.1	1.4	0.9
Other	0.3	0.4	0.5	0.5	0.2	0.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

Percentages of Employed Engineers by Major Fields and Sector of Employment (example)

Career Paths for Engineers

There are at least seven career options for graduating engineering students:

1) Corporate ladder
2) Independent entrepreneur
3) Military or government
4) Engineering and social service aboard
5) Professor/engineer
6) Graduate work outside engineering
7) A mix of first six options

ABET Engineering Curricula

Engineering programs approved by The Accreditation Board for engineering and Technology (ABET) includes a broad range of courses.

Why do I care about ABET accreditation?

- ABET audits engineering programs on a regular basis to assure that the program maintains high standards.
- Having an engineering degree from a four-year accredited engineering program is required to become a registered professional engineer.
- All degree programs in the College of Engineering at Georgia Tech are accredited by ABET

Engineering as a Profession

- Engineering possesses those attributes that typically characterize a profession;
- Satisfies an indispensable and beneficial need;
- Requires the exercise of discretion and judgment and is not subject to standardization.

Engineering as a Profession

- Involves activities that require knowledge and skill not commonly possessed by the general public;
- Has group consciousness for the promotion of knowledge and professional ideas and for rendering social services;
- Has a legal status and requires well-formulated standards of admission.

2.2. What types of Engineers are there?

- Field of Engineering Majors

Civil Engineering

Civil Engineering is Everywhere

- Civil Engineering is a composite of many specific disciplines.
  - Structural
  - Waste Treatment
  - Transportation
  - Geotechnical
  - Water Management
  - Construction Management

Building B

Buildings & Structures: Cities

Infrastructure: Transportation

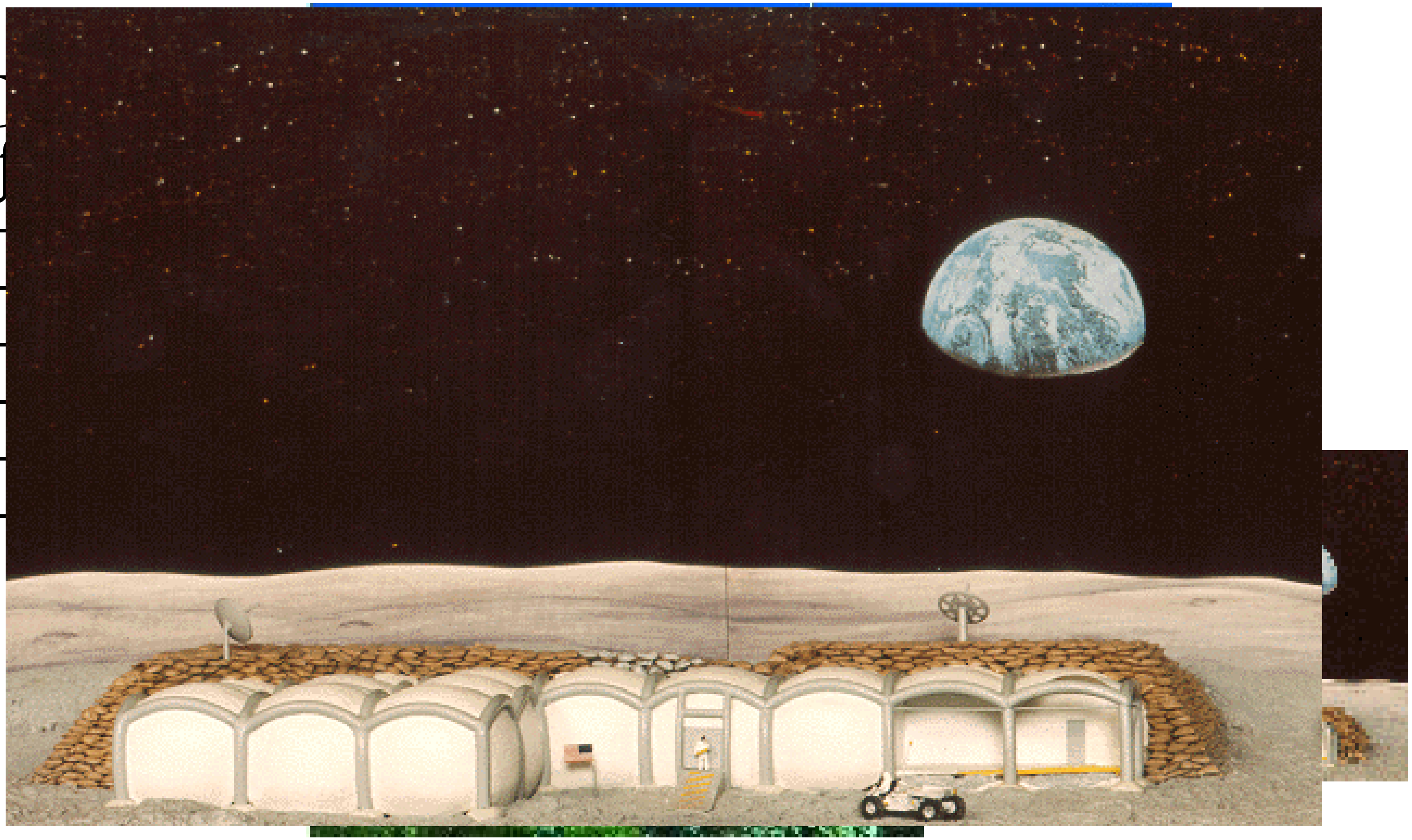
Culture: Art: Architecture

The Future: Without Limit!

Link: Building Big Site

What is Civil Engineering????

• C
of



Structural & Solid Mechanics

- Structural engineers design steel, concrete, or timber framed structures such as:
  - Tall buildings & towers,
  - Bridges,
  - Dams,
  - Retaining walls, & foundations, &.
  - Stadiums.

Waste Treatment & Environmental.

- Wastewater treatment engineers are civil or environmental engineers trained to design or analyze water treatment plants.
- Water treatment plants are categorized as follows:
  - Sanitary waste treatment facilities,
  - Industrial waste treatment facilities,
  - Potable (drinking) water treatment facility.

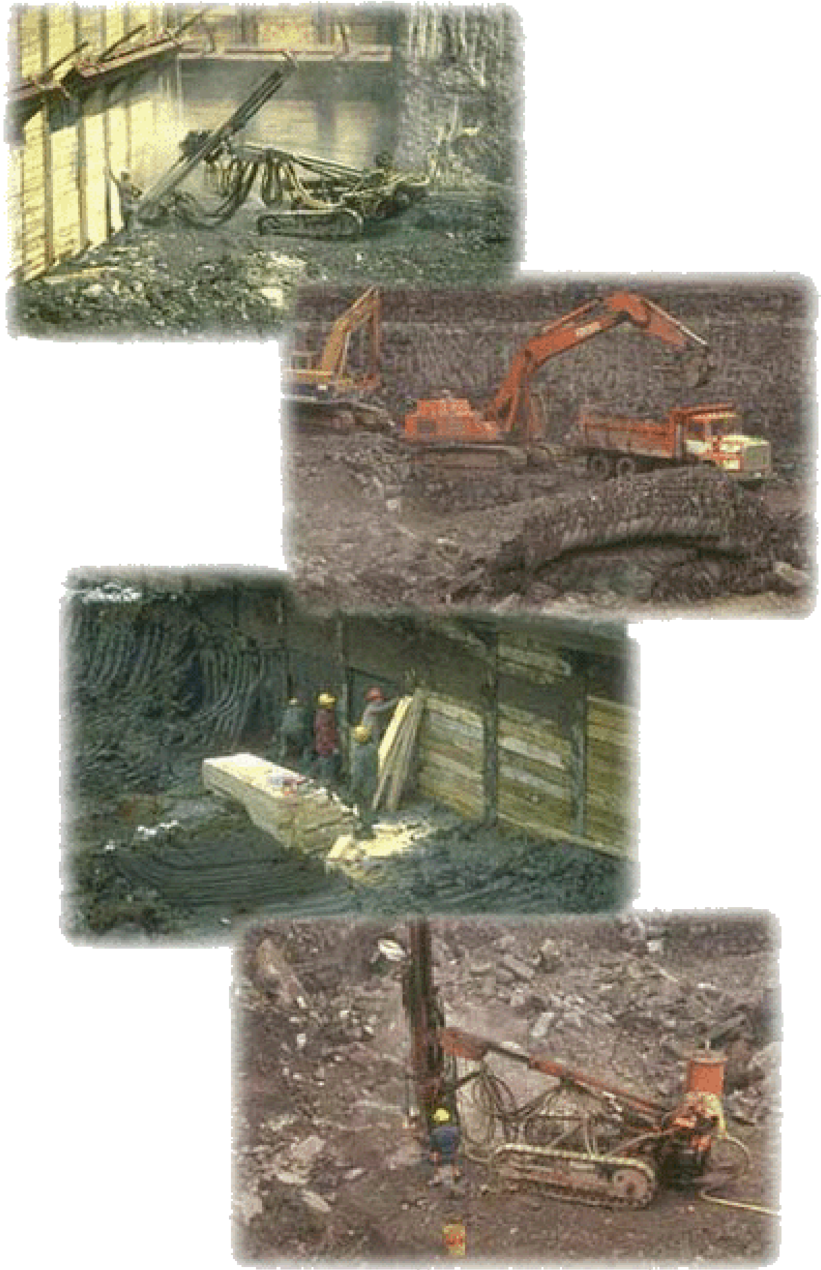
Largest treatment basins in the USA

Transportation

- Transportation Engineers design and analyze
  - Highways,
  - Railways,
  - Airports,
  - Urban and Suburban Road Networks,
  - Parking Lots, and
  - Traffic Control Signal Systems.

Geotechnical & Soil Mechanics

- Geotechnical Engineers analyze the subterranean rock and soil to determine its suitability to support extreme loads.
- Proper geotechnical engineering is essential for a safe and secure structure.



Hydraulics & Water Management

- Water management involves the use of hydrologic and hydraulic principles to design:
  - Drainage systems,
  - Detention/retention ponds,
  - Navigational waterways, and
  - Flood control levees, dams, and lakes.

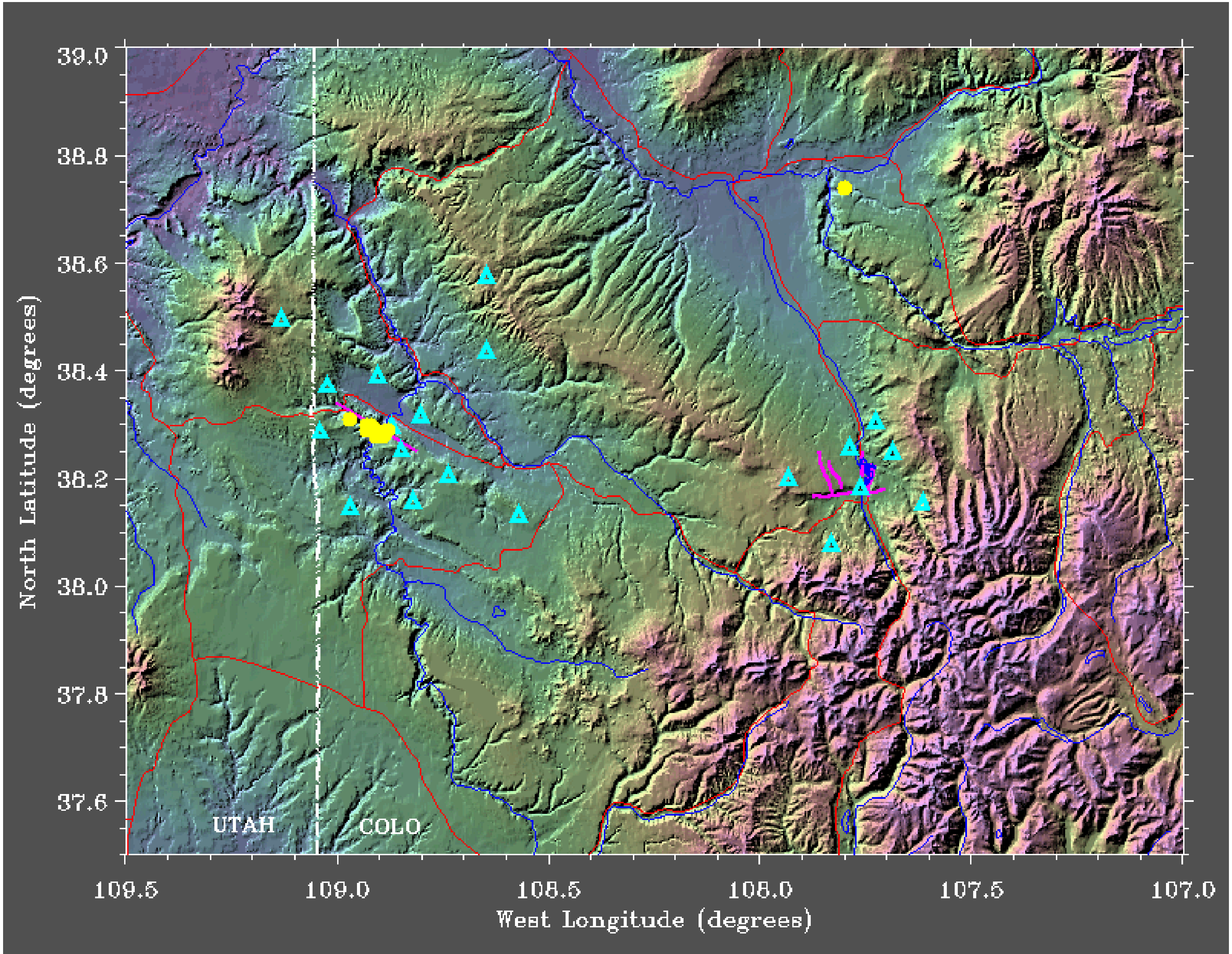
Construction Management

- Construction managers:
  - Review contracts,
  - Order materials,
  - Hire and schedule sub-contractors.
- The job of a construction manager is to:
  - Provide quality control and insure project is completed on time and.
  - Within budget.

Civil Engineering: 150 years in US

Croton Aqueduct, New Yor

- The American Society of Civil Engineers, a professional organization representing more than 123, 000 civil engineers, celebrates its 150th anniversary in 2002.



U.S. Bureau of Reclamation - Paradox Valley Seismographic Network

2.3 How Does An Engineer Do Things?

2.3 Engineering Functions: Testing

- Testing engineers are responsible for testing the durability and reliability of a product, making sure that it performs how it is supposed to, every time.
- Crash testing of a vehicle to observe effects of an air bag and crumple zone are examples of a testing engineer's duties

2.3 Engineering Functions: Design

- Design aspect is where largest number of engineers are employed
- Design engineers often work on components of a product, providing all the necessary specifics needed to successfully manufacture the product
- Design engineers regularly use computer design software as well as computer aided drafting software in their jobs

2.3 Engineering Functions: Design

- Design engineers must also verify that the part meets reliability and safety standards required for the product
- A concern always on the mind of design engineers is how to keep the development of a part cost effective, which is taken into account during a design process

2.3 Engineering Functions: Analysis

- Analysis engineers use computational tools and mathematic models to enrich the work of design and research engineers
- Analysis engineers typically have a mastery of: heat transfer, fluid flow, vibrations, dynamics, acoustics, and many other system characteristics

2.3Engineering Functions: Systems

- Responsible on a larger scale for bringing together components of parts from design engineers to make a complete product
- Responsible for making sure all components of a product work together as was intended by design engineers

2.3 Engineering Functions: Manufacturing & Construction

- Work individually or in teams
- Responsible for “molding” raw materials into finished product
- Maintain and keep records on equipment in plant
- Help with design process to keep costs low

2.3 Engineering Functions: Operations & Maintenance

- Responsible for maintaining production line
- Must have technical know-how to deal w/ problems
- Responsible for inspecting facility and equipment, must be certified in various inspection methods

2.3 Engineering Functions: Technical Support

- Works between consumers and producers
- Not necessarily have in depth knowledge of technical aspects of product
- Must have good interpersonal skills

2.3 Engineering Functions: Customer Support

- Often have more of a technical knowledge than Tech. Support, because they must be able to work with basic customers
- Evaluate whether or not a current practice is cost effective via feedback from customers

2.3 Engineering Functions: Sales

- Sales engineers have technical background, but are also able to communicate effectively w/ customers
- Job market for sales engineers is growing, due to the fact that products are becoming more and more technically complex

2.3 Engineering Functions: Consulting

- Are either self-employed, or work for a firm that does not directly manufacture products
- Consulting engineers might be involved in design, installation, and upkeep of a product
- Sometimes required to be a registered professional engineer in the state where he/she works

2.3 Engineering Majors
Mechanical Engineering

- Concerned with machines and mechanical devices
- Work in design, development, production, control, and operation of machines/devices
- Requires a strong math and physics background.

2.3 Engineering Majors: Aerospace Engineering

- Previously known as aeronautical and astronautical engineering
- First space flight Oct. 4, 1957 (Sputnik I)
- KEYWORDS:
  - **Aerodynamics:** The study of the flow of air over a streamlined surface or body.
  - **Propulsion engineers:** develop quieter, more efficient, and cleaner burning engines.

2.3 Engineering Majors: Aerospace Engineering

- KEYWORDS:
  - **Structural engineers:** use of new alloys, composites, and other new materials to meet design requirements of new spacecraft
  - **Control systems:** systems used to operate crafts
  - **Orbital mechanics:** calculation of where to place satellites using GPS

2.3 Engineering Majors: Agricultural Engineering

- Concerned with finding ways to produce food more efficiently
- KEYWORDS
  - **Harvesting Equip. -** removes crops from field, and begins processing of food
  - **Structures:** used to hold crops, feed, and livestock; Agricultural engineers develop and design the structures that hold crops

2.3 Engineering Majors: Agricultural Engineering

- **Food process engineers:** concerned with making healthier processed food products
- **Soil/Water Resources:** working to develop efficient ways to use limited resources

2.3 Engineering Majors: Architectural Engineering

- **Structural:** primarily concerned with the integrity of the building structure. Evaluates loads placed on buildings, and makes sure the building is structurally sound
- **Mechanical systems:** control climate of building, as well as humidity and air quality

2.3 Engineering Majors: Biomedical

- First recognized in 1940's
- Three basic categories: Bioengineering, Medical, and Clinical
- Bioengineering is application of engineering principles to biological systems
- Medical engineers develop instrumentation for medical uses
- Clinical engineers develop systems that help serve the needs of hospitals and clinics

2.3 Engineering Majors: Chemical

- Emphasizes the use of chemistry and chemical processes in engineering
- Chemical engineers develop processes to extract and refine crude oil and gas resources
- Chemical engineers also develop circuit boards, and work in the pharmaceutical industry, where processes are designed to create new, affordable drugs

2.3 Engineering Majors
Civil Engineering

- First seen in pyramids
- Structural engineers most common type of civil engineer
- **Transportation** engineers concerned w/ design and construction of highways, railroads, and mass transit systems
- Surveyors start construction process by locating property lines and property areas

2.3 Engineering Majors
Computer Engineering

- Focuses primarily on computer hardware, not software
- Work w/ electrical engineers to develop faster ways to transfer information, and to run the computer
- Responsible for the "architecture" of the computer system

2.3 Engineering Majors
Electrical Engineering

- More engineers are electrical than any other discipline
- With an ever growing technological society, electrical engineers will ALWAYS have a job
- Work in communications, microelectronics, signal processing, bioengineering, etc

2.3 Engineering Majors
Environmental Engineering

- Often coupled with Civil Engineering
- 3 aspects of environmental engineering:
  - Disposal: disposing of industrial/residential waste products
  - Remediation: clean up of a contaminated site
  - Prevention: working with corporations to reduce and/or prevent emissions and work to find ways to "recycle" products to be used again to reduce waste

2.3 Engineering Majors
Industrial Engineering

- **"Design, improvement, and installation of integrated systems of people, material, and energy"**
- Emphasis placed on: Production, Manufacturing, Human Factors Area, and Operations Research
- Production focuses on plant layout, scheduling, and quality control
- Human Factors focuses on the efficient placement of human resources within a plant/facility

2.3 Engineering Majors
Marine and Ocean Engineering

- Concerned with the design, development, and operation of ships and boats
- Marine engineer designs and maintains the systems that operate ships, I.e. propulsion, communication, steering and navigation
- Ocean engineer design and operates marine equipment other than ships, such as submersibles. O.E.s might also work on submarine pipelines and/or cables and drilling platforms

2.3 Engineering Majors
Materials Engineering

- Study the structure, as well as other important properties of materials, I.e. strength, hardness, and durability
- Run tests to ensure the quality of the performance of the material
- Material Engineers also study metallurgy, and the development of composites and alloys

2.3 Engineering Majors
Mining Engineering

- Work to maintain constant levels of raw minerals used every day in industrial and commercial settings
- Must discover, remove, process, and refine such minerals

2.3 Engineering Minerals
Nuclear Engineering

- Most concerned with producing and harnessing energy from nuclear sources
- Propulsion and electricity are the main uses of nuclear power
- Engineers also responsible for disposal of the nuclear waste byproduct, and how to keep people safe from harmful nuclear products

Decision Matrix: A tool

- A ***decision matrix*** is used to compare design solutions against one another, using specific criteria that are often based on project requirements.

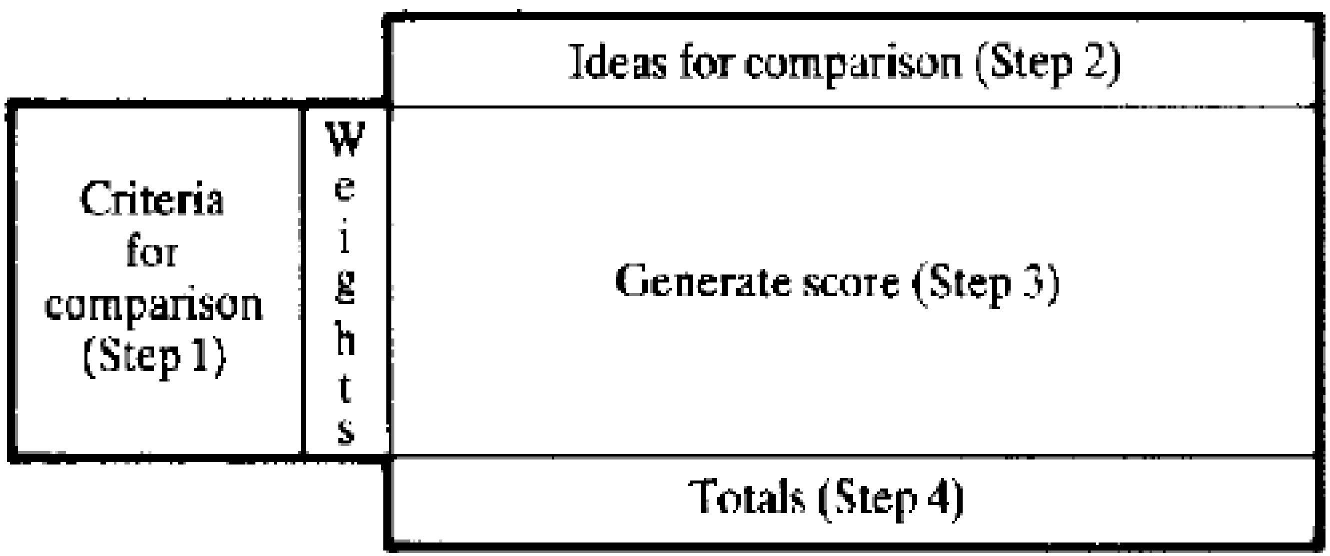
	cost	complexity	Development Time	Total
Idea #1	3	2	1	6
Idea #2	1	1	2	4
Idea #3	4	2	4	10
Idea #4	2	3	4	9
Idea #5	4	1	3	8
Idea #6	3	4	4	11

4	3	2	1
Best			Worst

2	1
Yes	No

Decision-Matrix (Pugh's method)

- A weighted decision matrix



Design Selection -Pugh's Method

The method is an iterative evaluation that quickly identifies the strongest design solution.

- Step 1 -Select the Criteria for Comparison

  The list of criteria must be developed from the customer needs and engineering specifications. All team members should contribute in making the list.

Design Selection -Pugh's Method

- Step 2 -Select the Design Solutions to be Compared

  The alternative design solutions should be those that proceed from the brainstorming.

- Step 3 -Generate the Score

  A favorite design solution should be selected as a ***datum***. All other designs are compared to it relative to each customer needs. For each comparison, the concept being evaluated is judged to be either better than ("+" score), about the same ("s" score), or worse than the datum ("–" score).

  Numeric scores can also be used.

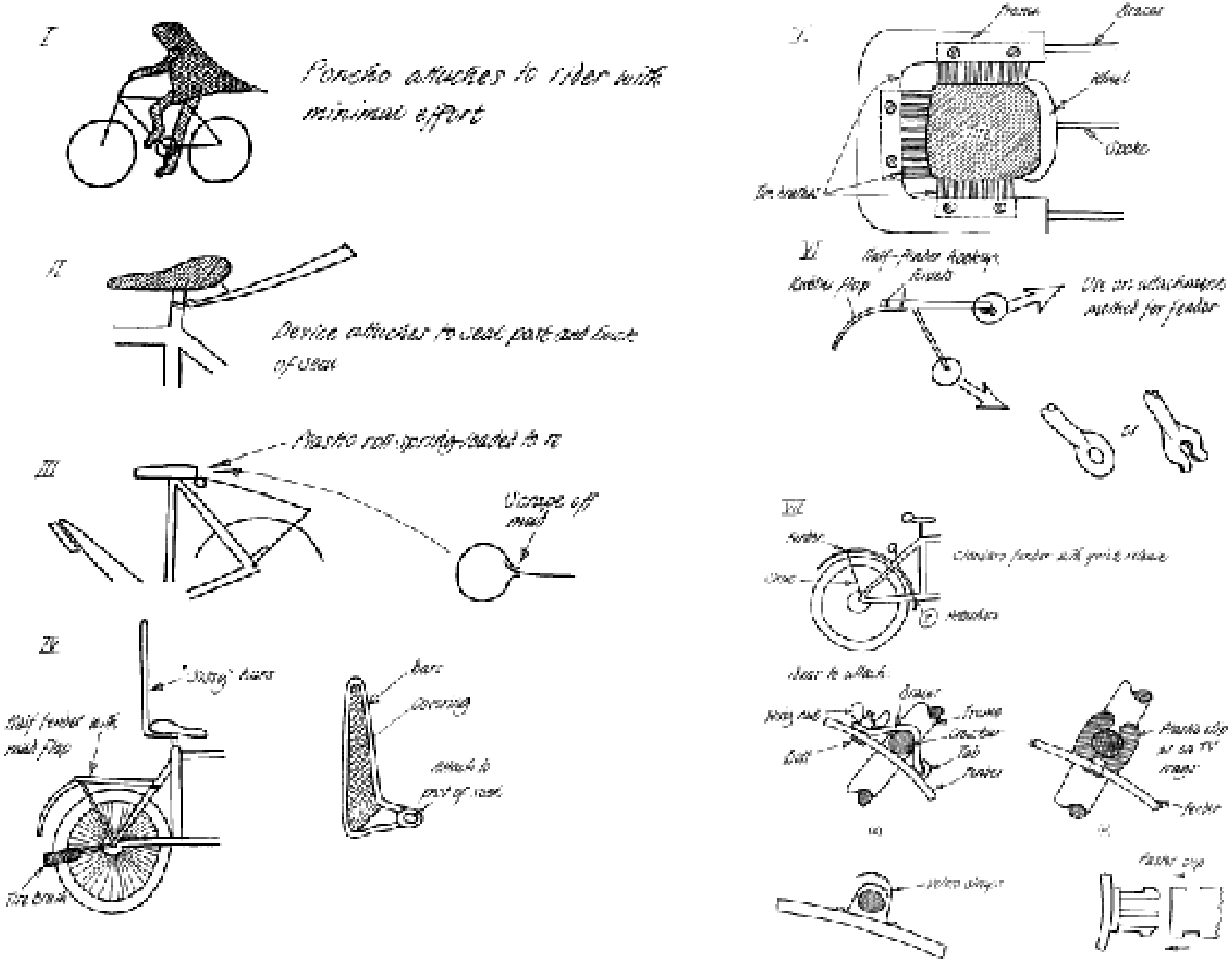
Design Selection -Pugh's Method

- Step 4 -Compute the total score

  Three scores are tallied, the number of plus scores, the number of minus scores and the total.

  If most designs get the same score on a certain criterion, examine that criterion closely. More knowledge may have to be developed in the area of the criterion.

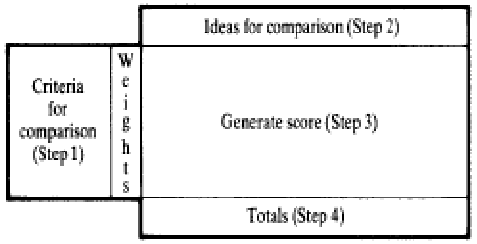
Bike Splashguard Concepts



Pugh's Method – Example

Bike splashguard

Initial decision matrix



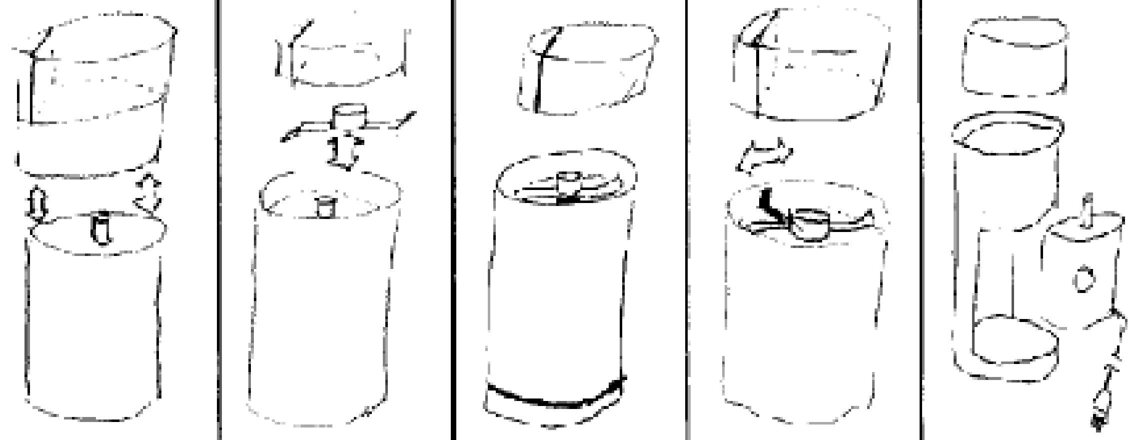
Best overall score, design II (5), should be used as a datum concept for the next step.

Concepts IV and V are rated as next best designs.

	Wt	I	II	III	IV	V	VI	VII
Easy attach	7	+	+	+	+	+	S	D
Easy detach	4	−	+	+	+	+	S	A
Fast attach	3	+	+	+	+	+	S	T
Fast detach	1	+	+	+	+	+	S	U
Attach when dirty	3	+	+	+	+	S	S	M
Detach when dirty	1	−	+	−	+	S	+	
Not mar	10	+	+	+	+	S	S	
Not catch water	7	−	+	−	S	S	S	
Not rattle	8	−	−	−	−	S	S	
Not wobble	7	−	−	−	S	S	S	
Not bend	4	−	−	−	S	−	S	
Long life	11	−	S	−	S	−	S	
Lightweight	7	+	S	S	−	S	S	
Not release accidently	10	+	S	S	S	S	S	
Fits most bikes	7	+	S	S	S	S	S	
Streamlined	5	−	S	−	−	+	S	
Total +		8	8	6	7	5	1	0
Total −		8	3	7	3	2	0	0
Overall total		0	5	−1	4	3	1	0
Weighted total		1	17	−15	9	5	1	0

Pugh's Method – Example

Coffee mill redesign concepts for cleanability



	Removable Chamber	Removable Blade	Washable	Scraper	Removable Unit
Cost	S	+	-	+	S
Store Grinder	S	+	+	+	S
Put in Beans	S	S	-	-	S
Take Out Coffee	S	-	-	-	-
Power Setup	S	S	S	S	S
Cleanable	S	-	S	-	S
Development Risk	S	+	-	+	S
$\Sigma+$	0	+3	+1	+3	0
$\Sigma-$	0	-2	-4	-3	1
Σ	0	+1	-3	0	-1

Numeric Scores Can Be Used

A numeric scale can be developed to assign values for each criteria category.

Rank Scale

4	3	2	1
Best			Worst

Question Scale

2	1
Yes	No

Identifying Criteria

- Cost
- Reusability
- Geometry
- Connections
- Cleanliness
- Resilience
- Testability

Other Types of Criteria

- Function
- Product life span
- Development time
- Size
- Material costs
- Development costs
- Manufacturing costs
- Company standards
- Manufacturing capabilities
- Safety

The Right Decision

Design decisions should be based on analysis and logic; not personal opinion.

A ***decision matrix*** is a design tool that may be used multiple times throughout a design process.

Some learning video showing

[Career Decision Matrix]

Watch, listen and learn.

Assignment No. 2
(Submit next meeting)

Make a decision matrix on what type of engineering field career you will consider to continue to study.

(Note: Watch the video and learn the sample decision matrix computation lecture of your professor.)

Lecture 3
Engineering Design Methods

C.M. Pascual
Professor, CACE

Topics

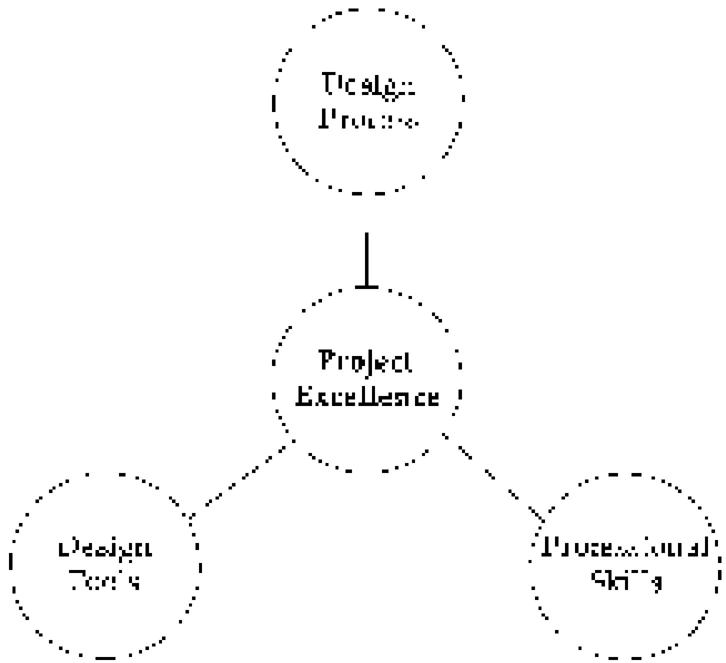
3.1. Elements of Engineering Design and the Process
3.2. Design Considerations
3.3. Design Methodology

ABET Definition of Engineering Design

- *Engineering design is the process of devising a system, component, or process to meet desired needs.*
- *It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective.*
- *Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation. [ABET]*

Achieving Excellent Project

- To achieve success in executing engineering and design projects, it takes an understanding of the design process, strong knowledge of design tools, and professional skills.



Success of Product:

Yesterday → Competing cost
Today → Quality
Tomorrow → Design

Engineering

- Engineer: One versed in the design, construction, and use of machines
- Engineers use methodical application of scientific knowledge and technology
  - Math, science and Fundamental technologies

Innovation + Methodical Application of Science

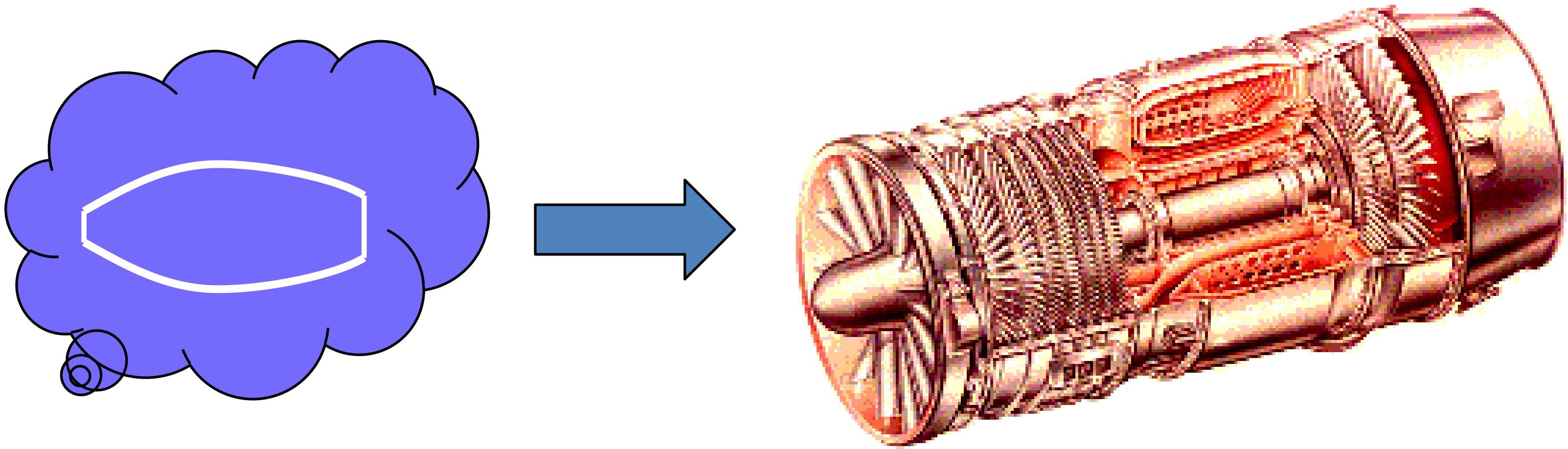
Effective Engineering/Design

Design Process

Design process is a collection of procedures and habits that help teams design better products

The Process of Design

- Designing is the process of making many decisions that converts an abstract concept into a hardware reality.



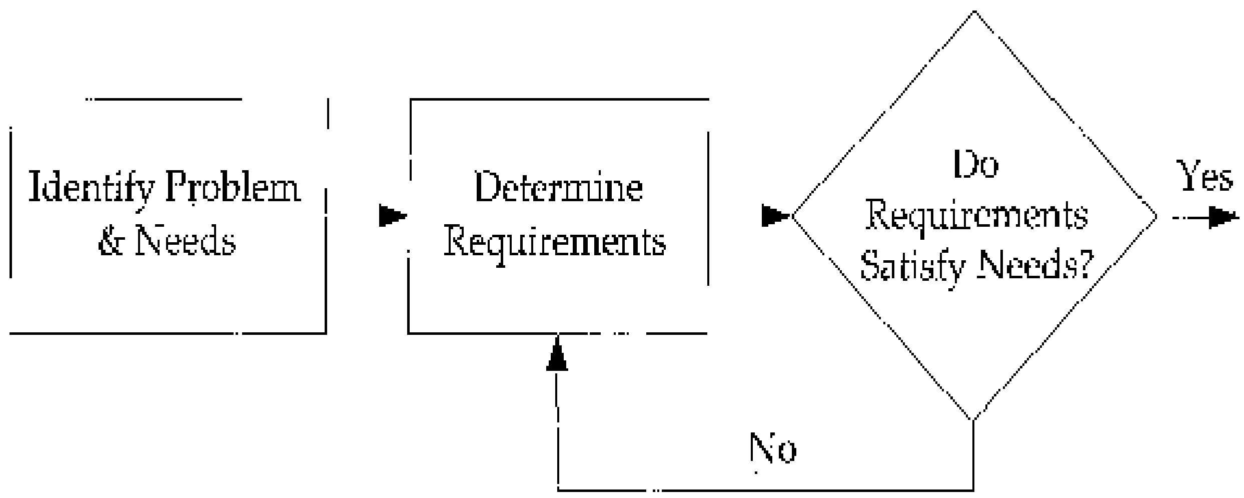
Concept　　　　　　　　　　　　　Product

7-Step Design Process

1. Problem definition (PDS)
2. External Search (Research)
3. Internal Search (Brainstorming)
4. Evaluation and Selection
5. Detail Design (Engineering)
6. Prototyping
7. Documentation

Design Process
Prescriptive or Descriptive?

- Prescriptive process for problem identification and requirements selection
  - Formal, exact sequences are defined
  - All aspects are clear
  - Good for defined problems and solutions



I. Aware of the World

- Sensitive to cultural differences, environmental concerns, and ethical principles.
- Alert to marketing opportunities both high and low tech.
- Cognizant of competitive talents, work ethics, and motivations.

II. Solidly Grounded

- Thoroughly grounded in the fundamentals of a selected engineering discipline.
- Has a historical perspective and remains aware of advances in science and their impact on engineering.
- Realizes that knowledge doubles at breakneck speed and is prepared to continue learning throughout a career.

III. Technically Broad

- Understands that real-life problems are multidisciplinary.
- Thinks broadly, seeing an issue in a rich context of various alternatives, possibilities, etc., rather than as a narrow quest to find a single answer.
- Been exposed to several disciplines.
- Is trained in systems modeling and the identification of critical elements. Understands the need to design experiments to verify computed analysis as well as meet specification requirements.
- Is psychologically prepared to embrace any field necessary to solve the problem at hand.

IV. Effective in Group Operations

- Cooperative in an organization of individuals working toward a common creative goal that is often multidisciplinary and multicultural in nature.
- Effective in written and oral communication.
- Willing to seek and use expert advice.
- Cognizant of the value of time and the need to make efficient use of the time [illegible].
- Understanding and respectful of the many facets of business operation — general management, marketing, finance, law, human resources, manufacturing, service, and especially quality.

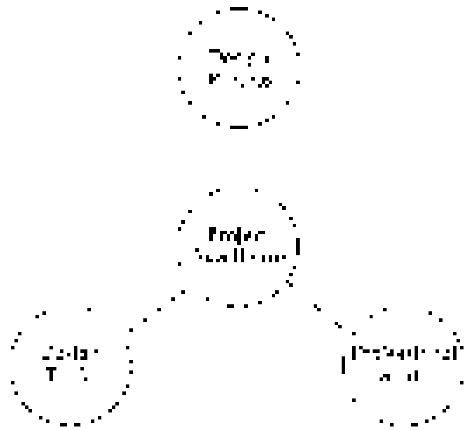
V. Versatile

- Innovative in the development of products and services.
- Sees engineering as an approach to problem solving in general.
- Capable of applying engineering beyond the typical employment focus of engineering graduates in the manufacturing industries, to the much broader economy (financial services, health care, transportation, etc.) where engineering skills could make a dramatic improvement in the productivity of those segments of the economy, which employ 80 percent of the U.S. population.

VI. Customer Oriented

- Realizes that finding and satisfying customers is the only guarantee of business success.
- Understands that products and services must excel in the test of [illegible] effectiveness in the global market place.

The World-Class Engineer.
(Leonhard Center for the Advancement of Engineering Education,
The Pennsylvania State University)



Strong technical stills
and understanding of
the design process

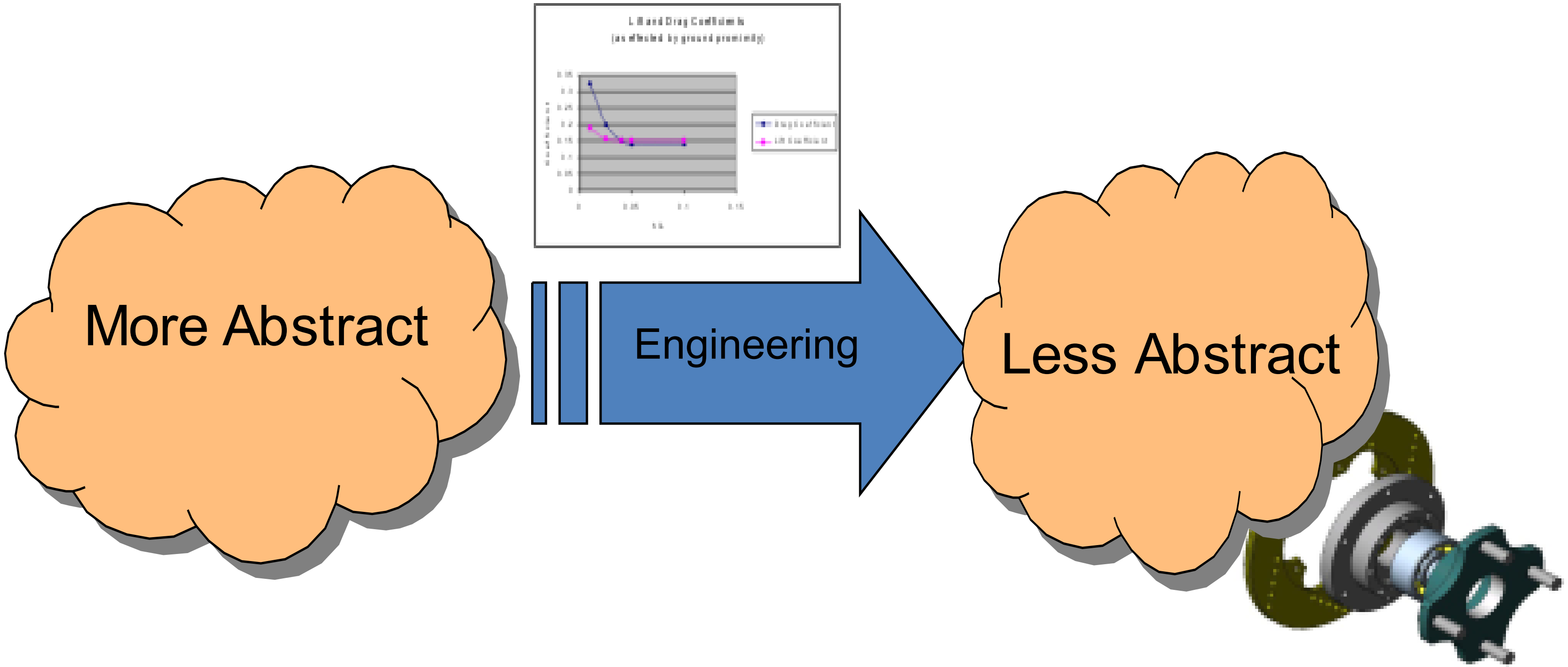
Elements of Design Process

- Problem Identification
- Research Phase
- Requirements Specification
- Concept Generation
- Design Phase
- Prototyping Phase
- System Integration
- Maintenance Phase

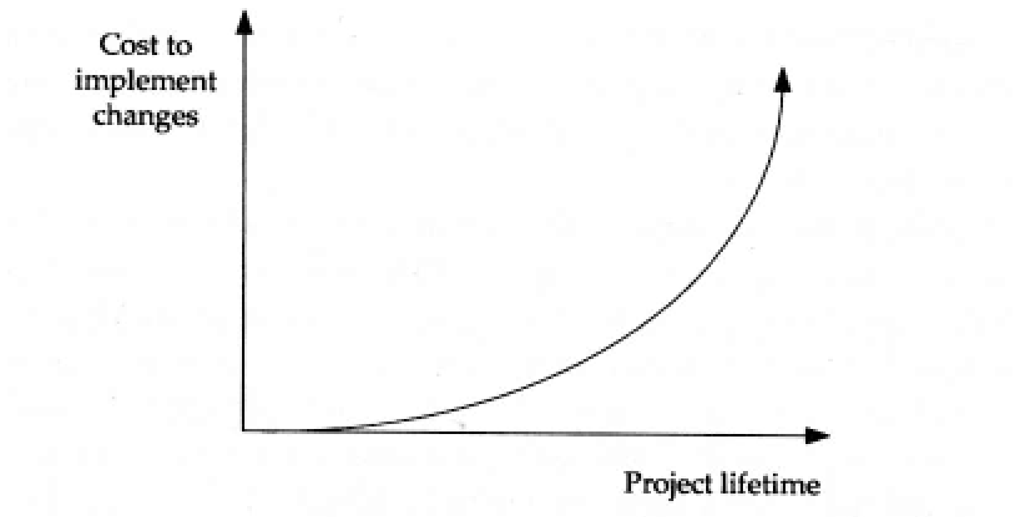
The Engineering Design Process

- Creative process
- Problem solving - the big picture
- No single "correct" solution
- Technical aspects only small part

Detail Design (Engineering)



Cost of Design Changes



- Costs increase exponentially as the project lifetime increases

Problem Identification and Requirements Specification

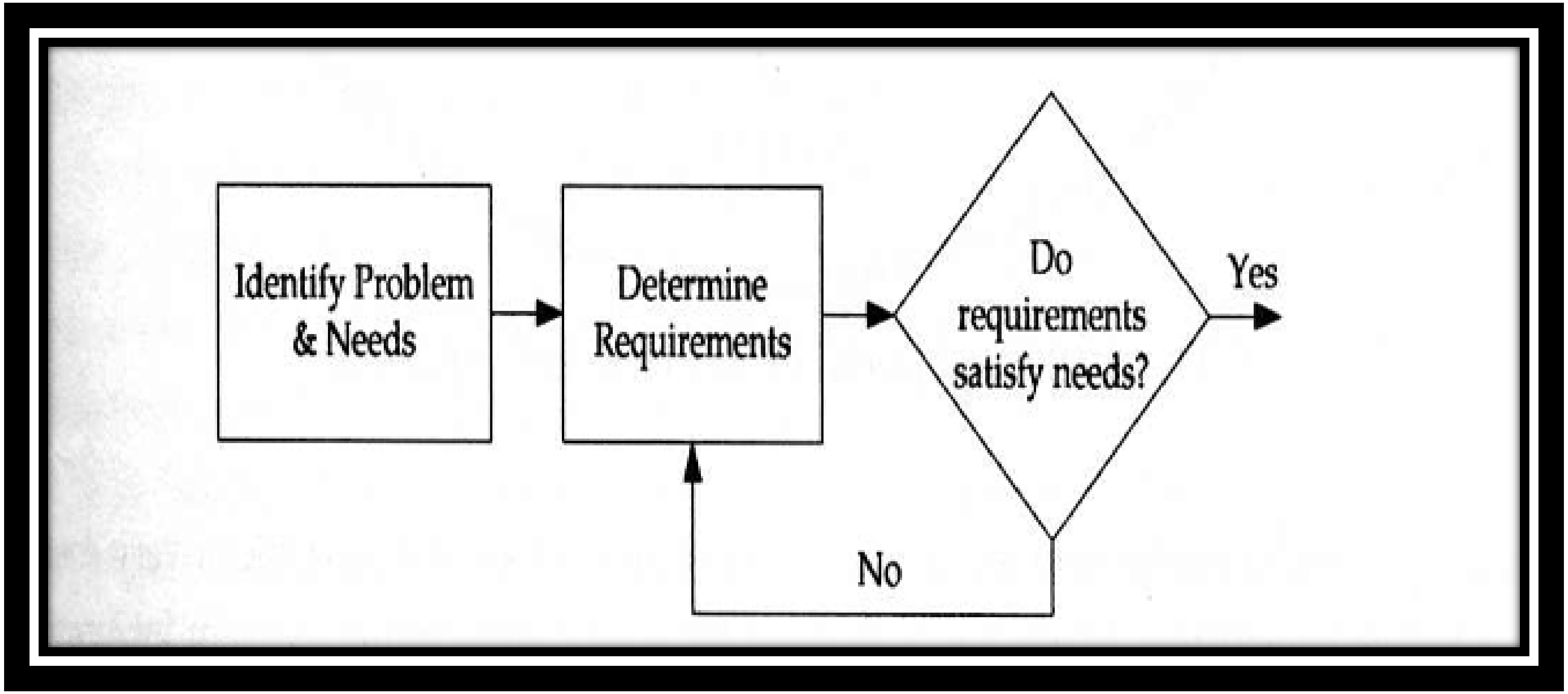


Fig. 3.1. A prescriptive design process for problem identification and requirements selection.

Needs Identification

- What is the Problem?
  1. Collect information
  2. Interpret information
  3. Organize needs hierarchy
  4. Determine relative importance of needs
  5. Review outcomes and process

Example Needs Hierarchy

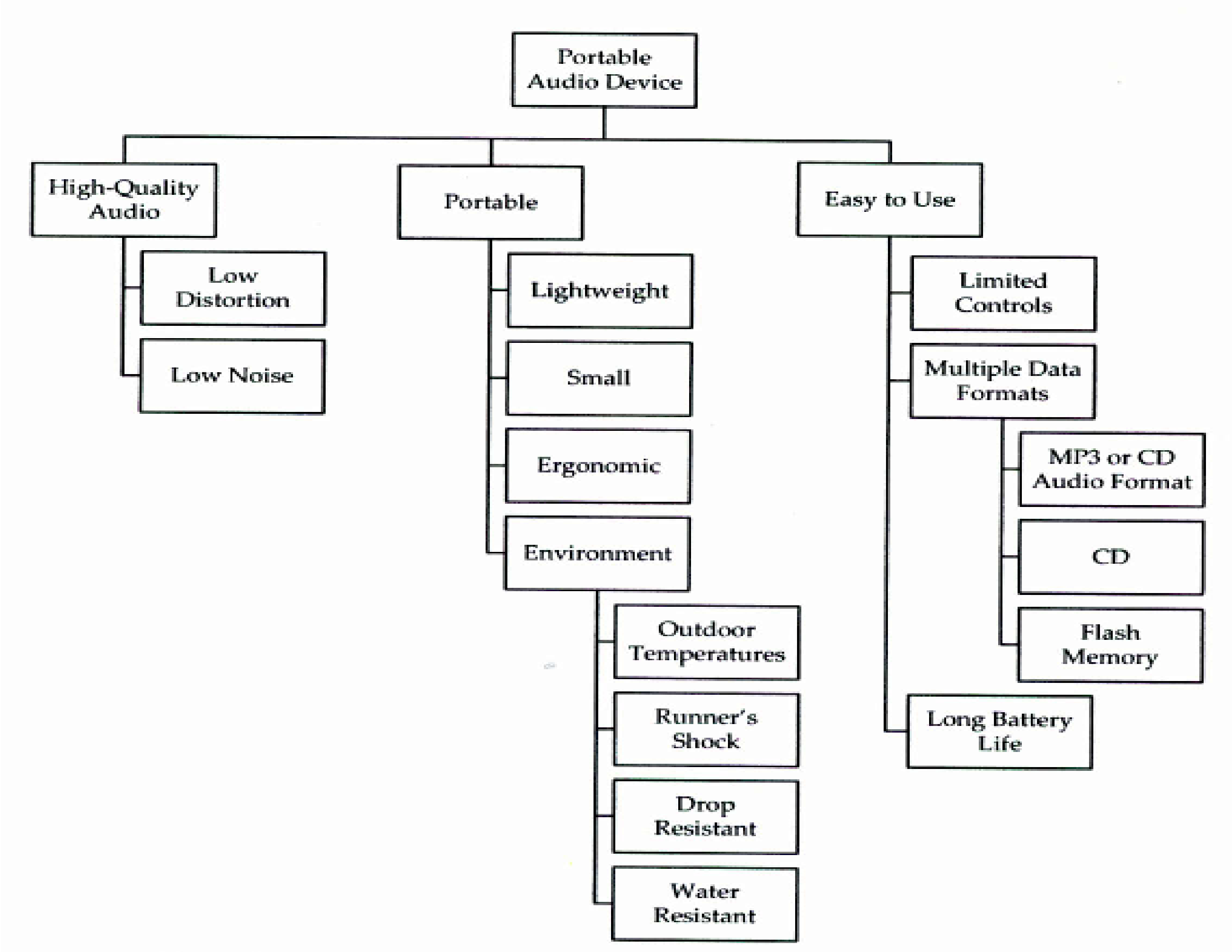


Fig. 3.2. Objective tree for a portable audio deice to be used by runners.

Problem Statement

- Example 3.1
  - Need: Drivers have difficulty seeing obstructions in all directions
  - Objective: design system to avoid accidents

Requirements Specification

- Identifies requirements design must satisfy for success

1. Marketing requirements
   - Customer needs
2. Engineering requirements
   - Applies to technical aspects
   - Performance requirements

Properties of Engineering Requirements

1. Abstract - what, not how
2. Unambiguous - unique and specific
   - Unlike marketing requirements
3. Traceable - satisfy need?
4. Verifiable - test/measure

Example Engineering Requirements

- **Performance and Functionality**
  1. Will identify skin lesions with a 90% accuracy
  2. Should be able to measure within 1mm

- **Reliability**
  1. Operational 99.9% of the time
  2. MTBF of 10 years

- **Energy**
  1. Average power consumption of 2 watts
  2. Peak current draw of 1 amp

Properties of Requirements Specification

1. Normalized (orthogonal) set
2. Complete set
3. Consistent
4. Bounded
5. Granular - system vs. component
6. Modifiable

- *From IEEE Std. 1233-1998*

Constraints

- Economic
- Environmental
- Ethical and Legal
- Health and Safety
- Manufacturability
- Political and Social - FDA, language?
- Sustainability

Standards

- Examples - RS-232, TCP/IP, USB
- Types
  - Safety
  - Testing
  - Reliability
  - Communications
  - Documentation
  - Programming Languages

Concept Generation and Evaluation

- Explore many solutions
  - Brainstorm
- Select the best solution
  - Based on needs and constraints
- Creativity
  - Development of new ideas
- Innovation
  - Bringing creative ideas to reality

Creativity

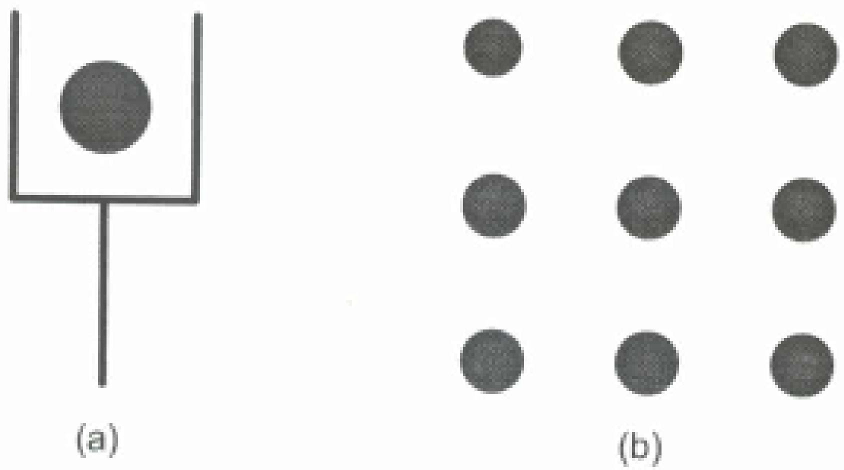


Figure 4.1 (a) The shovel problem. Think of this as a shovel with a coin on the spade. The objective is to move two lines so that the coin is no longer in the spade, but there is still a shovel. (b) The nine dot problem. Draw four connected straight lines that pass through all nine dots.

Barriers to Creativity

- Perceptual blocks
  - Limiting problem space
- Emotional blocks
  - Fear of failure - "fail early and often"
- Environmental blocks
  - Engineering cultural bias
- Intellectual and expressive blocks
  - Understand tools

Strategies to Enhance Creativity

- Lateral thinking
- Question
- Practice
- Suspend judgment
- Allow time
- Think like a beginner

Concept Generation

- Substitute - new elements
- Combine - existing elements
- Adapt - different operation
- Modify - size, shape, function
- Put to other use - other app domains
- Eliminate - parts or whole
- Rearrange or reverse - work better

Concept Table

Table 4.1 A concept table for generating ideas for a personal computing system. The potential solution is identified by the combination of circled elements.

User Interface	Display	Connectivity & Expansion	Power	Size
Keyboard	CRT	Serial & Parallel	Battery	Hand-held, Fits in pocket
Touchpad	Flat Panel	USB	AC Power	Notebook size
Handwriting Recognition	Plasma	Wireless Ethernet	Solar Power	Wearable
Video	Heads-up Display	Wired Ethernet	Fuel Cell	Credit Card Size
Voice	LCD	PCMCIA	Thermal Transfer	Flexible in shape
		Modem / Telephone		

Concept Evaluation

Table 4.3 A strengths and weaknesses analysis of proposed methods for heating an Intel 1000XF card to be used in lifetime testing. [Ese03].

Method	Strengths	Weaknesses
Contact Heating	• Simplest design • Could be used internally to computer	• Does not create uniform temperature • Hard to control temperature
Temperature Chamber	• Uniform temperature • Greater control over temperature	• Must be external to computer • More difficult to design • Expensive

Table 4.4 A simple decision matrix.

	Design Concept 1	Design Concept 2	Design Concept 3
Criteria 1	2	5	4
Criteria 2	1	3	2
Criteria 3	3	1	1
Criteria 4	4	4	3
Score	10	13	10

Design Considerations

1) WORST CASE DESIGN

- **Component variation**
- **Environmental conditions**
- **Use computer simulations**

Design Considerations

2) RELIABILITY

- measured by MTBF, failure rate = 1/MTBF

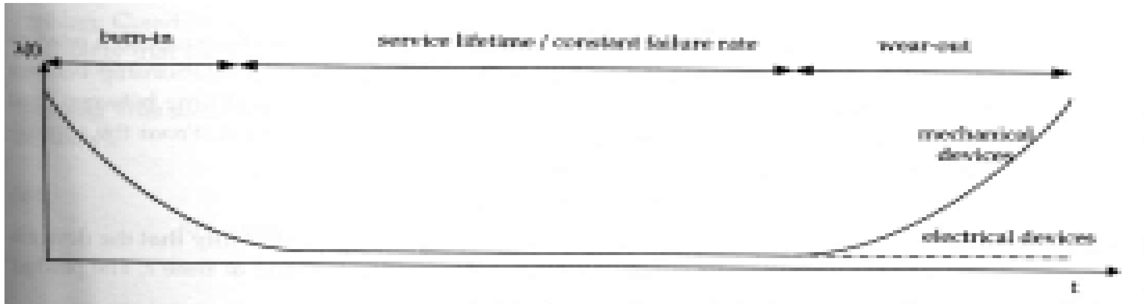


Figure 8.6 Failure rate as a function of time, also known as the bathtub curve.

- mech
- design redundancy into system
- simple system/fewer parts = more reliable

Design Considerations

3) SAFETY
- identify failure modes
- provide protection

4) TEST
- design for ease of test

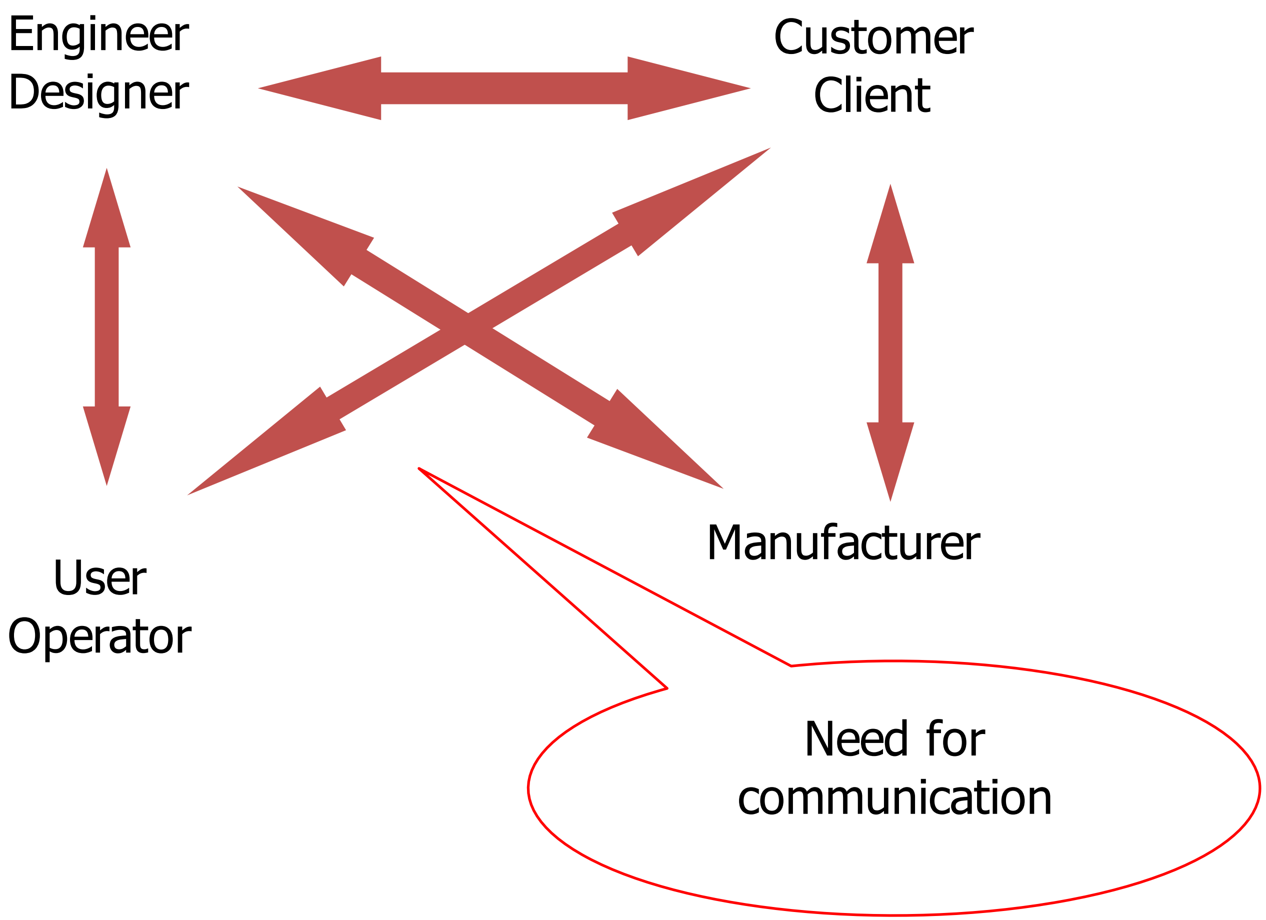
5) PRODUCTION/ MANUFACTURING
- consider ease of assembly

3.2. FUNDAMENTALS OF ENGINEERING DESIGN

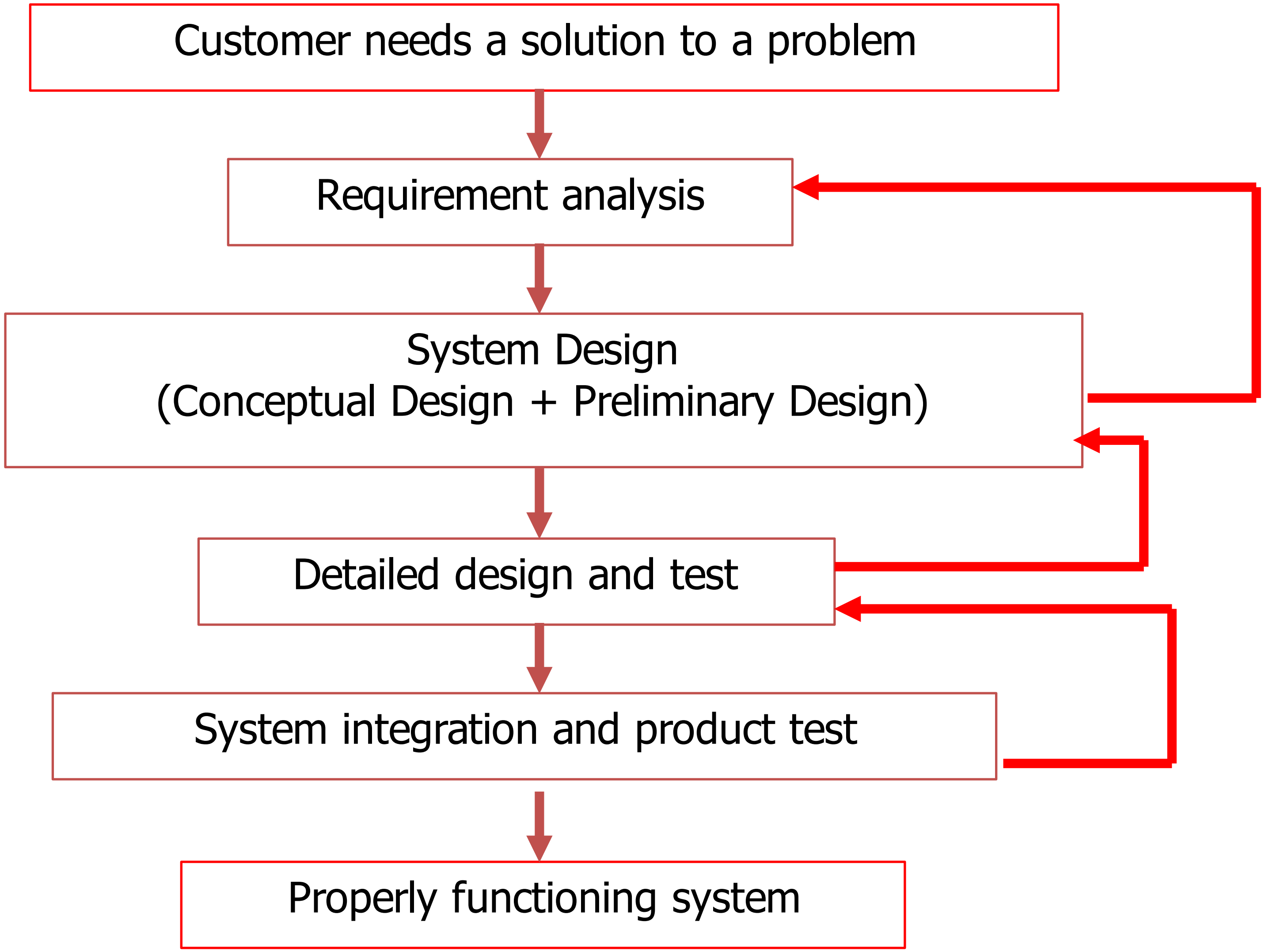
Outline

- Introduction to engineering design
- Engineering design process
- Documentation and writing technical reports

The role of the design engineer



Design Process



Requirement Analysis

Customer needs a solution to a problem

↓

Assess needs

↓

Statement of problem

↓

Specify design requirements

↓

Requirement specifications

Requirement analysis

Needs assessment

- The aim is not to solve the problem but to understand what the problem is
  - What does this client want?
  - What is the problem that the design is to solve?
- The objectives (goals) and constraints of the problem should be identified
  - Objectives: summary of the needs that the design is to satisfy (helps us to choose among alternative design configurations)
  - Constraints: the design must satisfy (takes logical values 0 or 1, helps to decide acceptable or not)

Customer needs a solution to a problem

↓

Assess needs

↓

Statement of problem

↓

Specify design requirements

↓

Requirement specifications

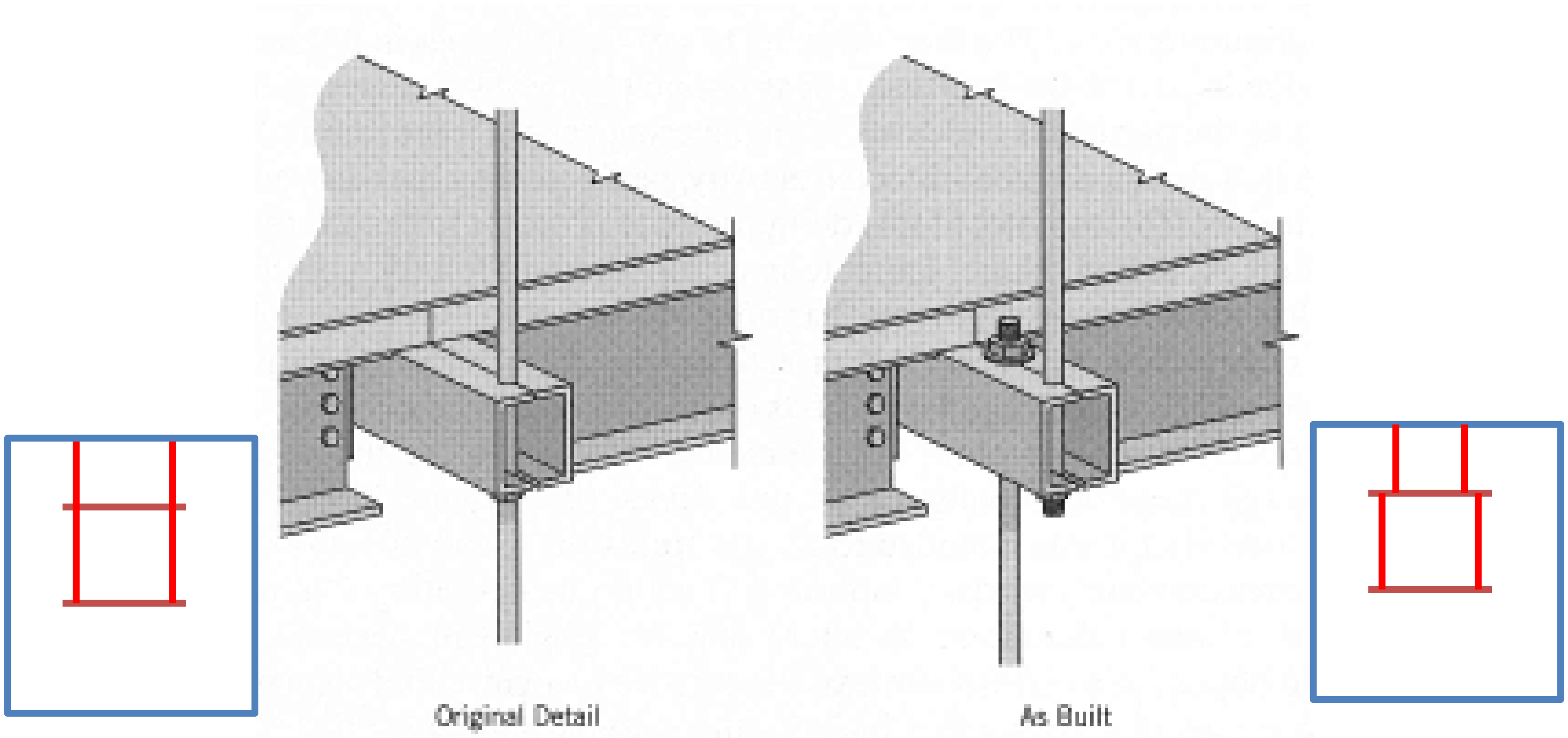
How to assess needs? (1/2)

- Question the customer
  - To define the design problem
  - To understand budget and schedule constraints
  - Reliability and maintenance constraints
- Explore resources
  - Expertise (knowledge and experience)
  - Technical literature (books, journals,www)
  - Measurement and testing equipments (equipment suppliers)
  - Similar designs (competitors, patent search)

How to assess needs? (2/2)

- Search legal and regulatory restrictions
  - Allocation of frequency bands
  - Restriction on tower heights
  - Environmental impacts
  - Safety
- Manufacturability issues

Importance of manufacturability and communication



Second floor collapsed, 114 people died

Requirement analysis

Statement of the problem (1/3)

- In the language of the customer, normally straightforward, non technical and non quantifiable

Customer needs a solution to a problem

↓

Assess needs

↓

Statement of problem

↓

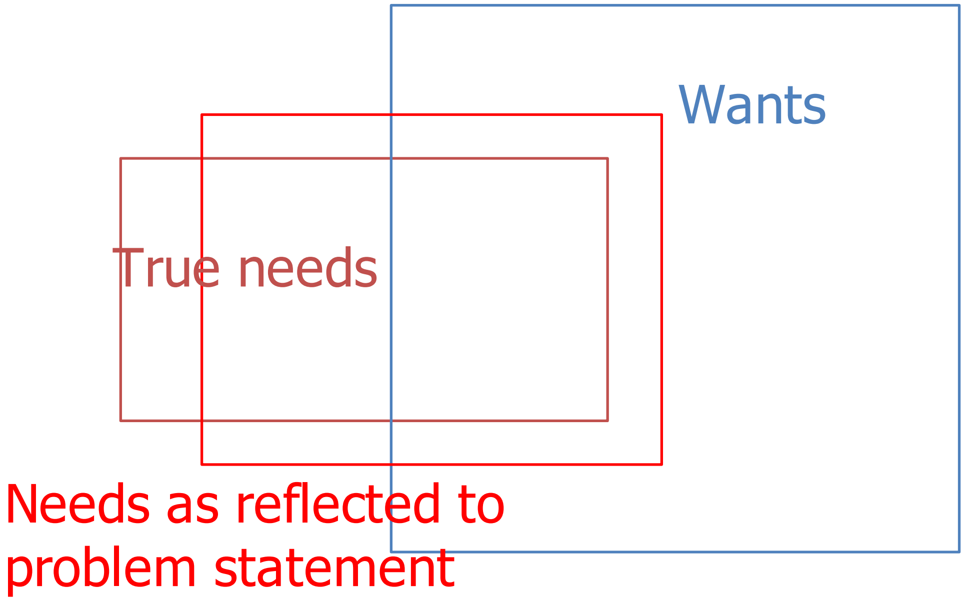
Specify design requirements

↓

Requirement specifications

Statement of the problem (2/3)

- Tools that help
  - Question the customer
  - Differentiate Needs and Wants



Statement of the problem (3/3)

- Make Input/Output Analysis
- Preview the user interface and operation of the device

Objective trees

- Make a list of objectives according to the assessed needs and restrictions
- Group the relevant objectives
- Form a hierarchical tree structure

Specify design requirements

Requirement analysis

- Translating client and user needs into terminology that helps us find ways to realize those needs and measure how well we met them
  - How will everyone that takes part in the design know that it is done?
  - It turns the problem statement into a technical, quantified specification
- Sets out criteria for verifying that the design meets its intended objectives
- Describes the test for verification

Customer needs a solution to a problem

Assess needs

Statement of problem

Specify design requirements

Requirement specifications

Specifications

- How can I express what the client wants in terms that helps me as an engineer
- Expressible as numbers and measures
- Precise description of the properties of the object being designed

Specification types (1/2)

- Design specs : provide basis for evaluating the design
- Functional specs: what the thing must do?
  - Input-output relations
  - Black boxes and transparent boxes

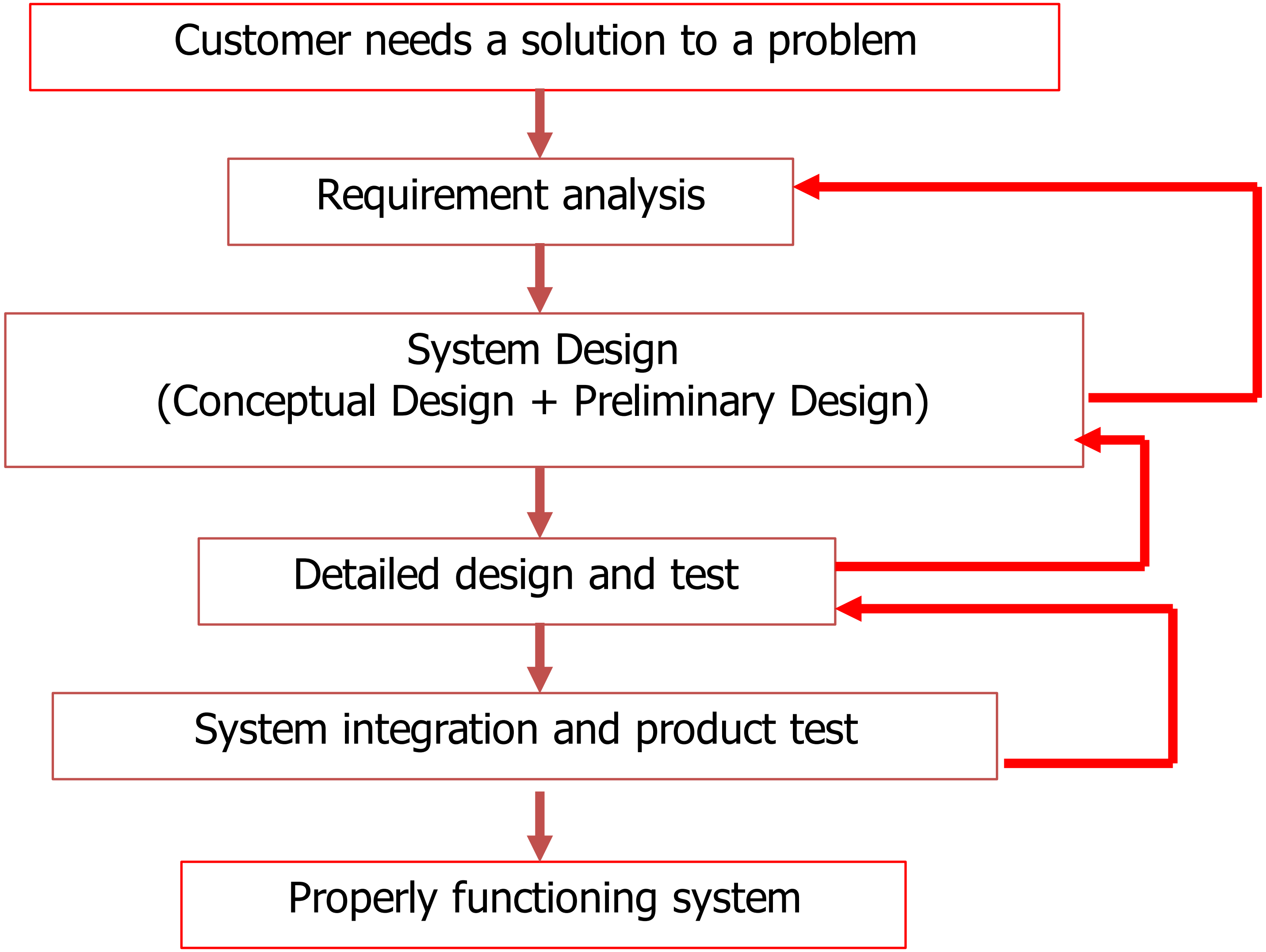
Specification types (2/2)

- Performance specs: tells us how well the design is
- Metrics : Tools for testing and measuring the performance

Documentation

- Overview (executive summary)
- Statement of the problem
- Operational description (draft user's manual)
- Requirement specifications
- Design deliverables
- Preliminary system test plan
- Implementation considerations
- Service and maintanence
- Manufacture
  - Appendices
    - A: Studies (experimental results)
    - B: Relevant standards and legal and regulatory restrictions

Design Process



System Design

- Conceptualization
- Synthesis
- Analysis

Conceptualization

- Develop a rough, early form of solution
- An idea or notion that can be a solution
- Primitive solutions, no definite form or character
- Lack organization and structure

Idea generation

- Brainstorming
  - Seek quantity of concepts not quality
  - No judgement or analysis of concepts
- Search similar designs
  - Patents: no need to reinvent the wheel

Synthesis

- Create a well-defined structure for the concept
- Sufficient detail that helps analysis
- Preliminary design
- Block diagram of the system
- Each block will be designed in the detailed design

Block-diagram basics

- Implementable with a single technology
  - analog or digital
- Common functions grouped in one block
  - common power supply
- Try to avoid feedback loops between blocks
  - designed by different engineers, may be unstable
- Keep in mind the standards
  - Logic 0/1 voltage levels for TTL and MOS technologies
- Specify the parameters of analog signals
  - Frequency, BW

Analysis

- Determine if the synthesized system meets the objectives
- Determine the risks
- Develop mathematical model for the blocks
- Analyze (simulations or experiments)
- Go back to synthesis, refine a solution
- Analyze again
- Evaluate the alternative solutions
- Choose one solution

Documentation

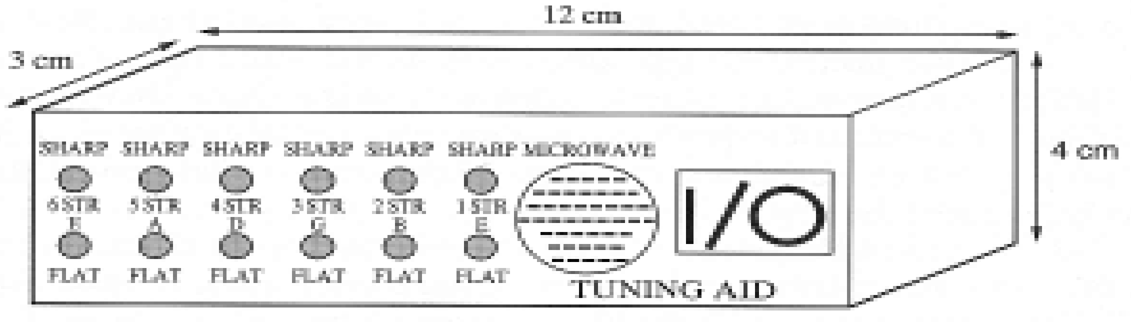
- The concept
  - Explain the principle of operation
  - Background information
- The block diagram
  - With specification of inputs and outputs
- Functional description of the blocks
  - Subsection for each block
- Description of the system
  - How the blocks interact with one another to make the system work
- System analysis
  - Results of mathematical analysis, simulations and experiments and evaluations

Example

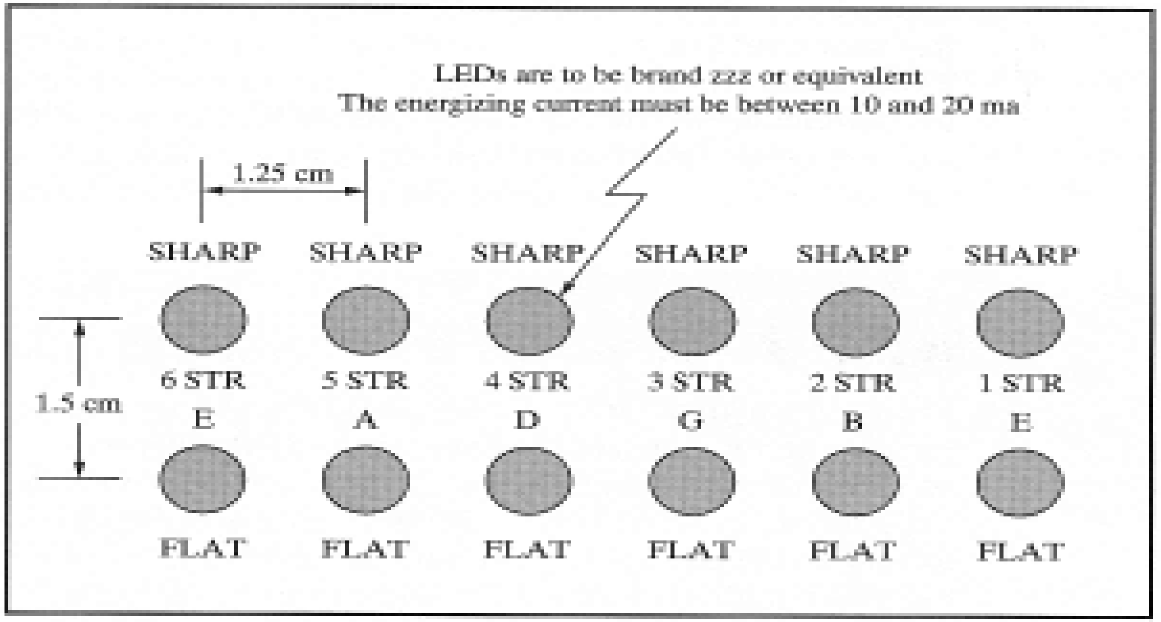
- Customer needs a solution to a problem of designing a guitar tuner

- Problem Statement
  - The accuracy of the device will be measured by the difference between the pitch of a tuned string and the correct pitch. The limits should be well within those of a guitar that has been professionally tuned and then played for one week without further tuning

The guitar tuner

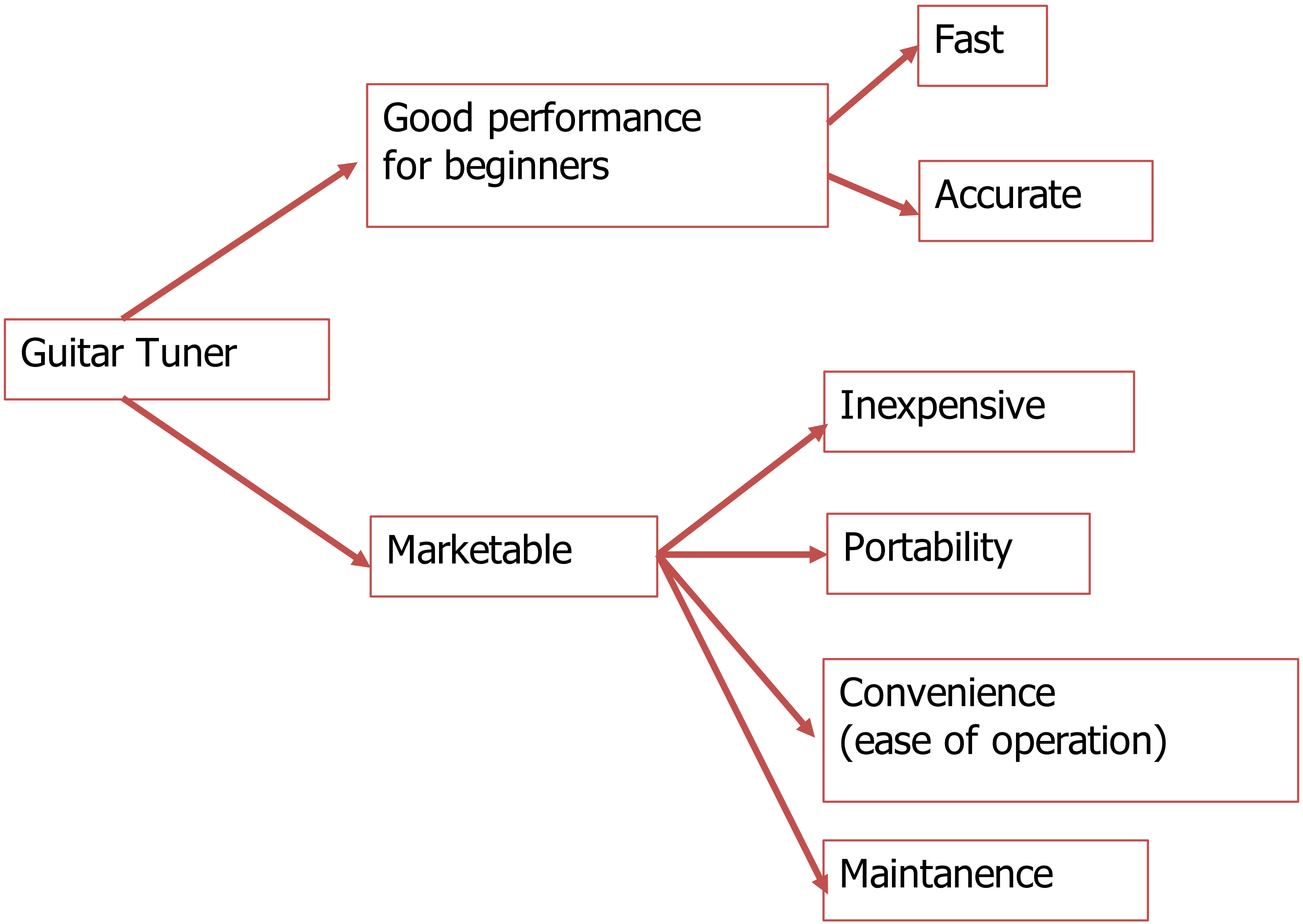


(a)



(b)

Objective trees



Ranking objectives

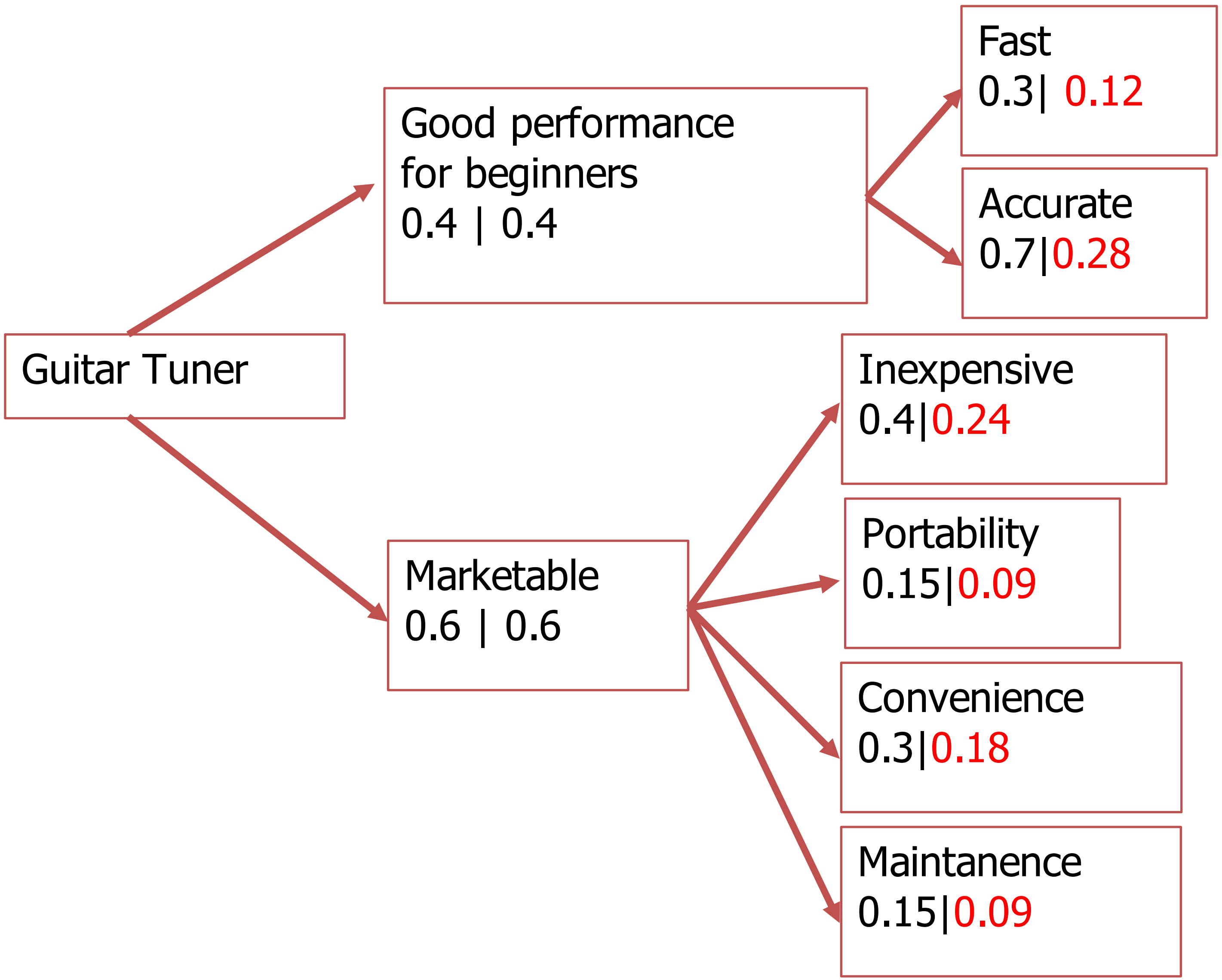
Pairwise comparison charts

	P Portability	I Inexpensive	C Convenience	M Maintenance	Total
P	-	0	0	1/2	1/2
I	1	-	1	1	3
C	1	0	-	1	2
M	1/2	0	0	-	1/2

Weighted objectives

	Ranking points	Add 1	Weighted objectives
P	1/2	1.5	1.5/10=0.15
I	3	4	4/10=0.4
C	2	3	3/10=0.3
M	1/2	1.5	1.5/10=0.15
		Sum=10	Sum=1

Weighted objective trees



How to specify design requirements

- Search out expert sources
  - The guitar can drift up to 20 cents in a week
    - f1 is X cents higher than f2: $f1/f2=2^{X/1200}$
- Analyze similar designs (reverse engineering)
  - Precision tuners have an accuracy of ±2 cents
- Conduct tests and experiments
  - Signal levels and response time

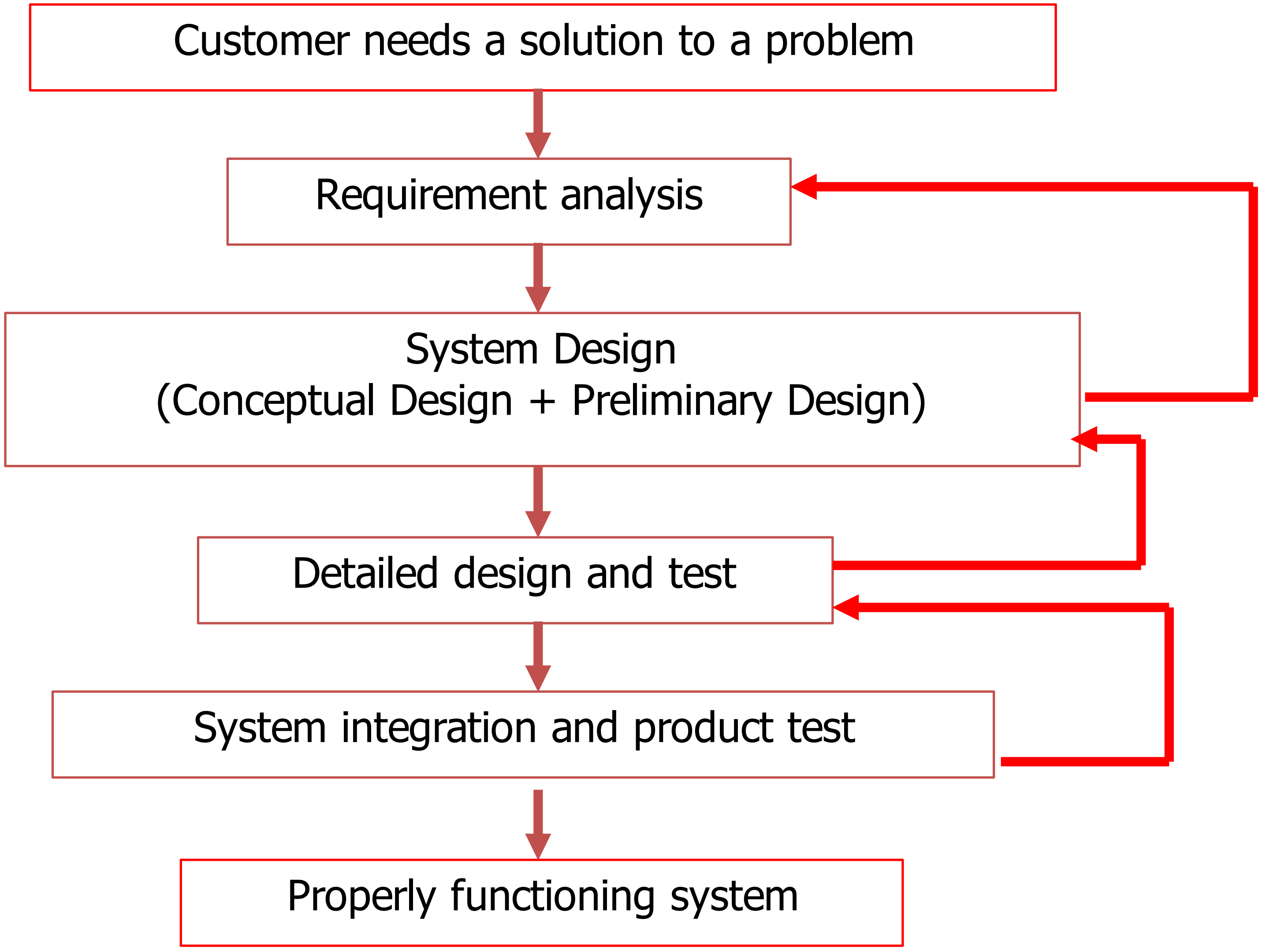
- Performance specs:
  - Accuracy requirement is ±6 cents
- Metrics :
  - Compare with a professional tuner
    (6+2 = ±8 cents)

Evaluation

	F 0.12	A 0.28	P 0.24	I 0.09	C 0.18	M 0.09	Total
S1	8 0.96	6 1.68	4 0.96	2 0.18	0 0	2 0.18	3.96
S2	0 0.0	6 1.68	10 2.4	8 0.72	2 0.36	2 0.18	5.34
S3	4 0.48	4 1.12	6 1.44	2 0.18	2 0.36	8 0.72	4.3
S4	2 0.24	8 2.24	2 0.48	6 0.54	10 1.8	4 0.36	5.66

10: Excellent,8: Good, 6: Satis., 4: Av., 2: Unacceptable, 0: Failure

Design Process



Detailed Design,System Integrations and Tests

- Develop detailed design of each block specified in the system design
- Implement, test, and verify each block
- Integrate system, produce prototype
- Test system according to the test plan developed in requirements specification document
- Verify design, iterate if necessary
- Prepare detailed design documentation

Documentation

- Main deliverable of the design project
- Used to build and test the product in the factory
- Block diagrams and functional description
  – To allow upgrades and extensions
- Shematic diagrams, PCB layouts, parts list
  – For manufacturing engineers and technicians
- Key points in the circuit, test procedures and test fixtures
  – For technicians in the repair department

3.3. Design Methodologies

Design Methodologies: Top-Down

- **Also called “functional decompostion“**
- **implementation details considered only at the lowest level**
- **top-down design, is not so clean and linear in practice**
- **Often implementation-level commitments are made at high levels in the design process**

Design Methodologies

CASE-BASED:

- Research a specific, similar design case study
- Model your process on that

INCREMENTAL REDESIGN:

- Find an existing design and "unravel" the design from the bottom up
- Modify as required
- Detailed and least global aspects of the design are explored and redesigned, if necessary, first

Design Methodologies

ITERATIVE REFINEMENT:

- **An iterative top-down approach**
- **First a rough, approximate and general design is completed**
- **Then we do it finer, more exact and more specific**
- **This process continues iteratively until the complete detail design in done**

Design Methodologies

BOTTOM-UP DESIGN:

- Opposite of top-down
- Start at the bottom with detail design
- To do this, you must have some idea of where you are going. So, often this becomes...

HYBRID DESIGN:

- Combines aspects of both top-down and bottom-up
- More practical design approach then pure top-down
- Start with a top-down approach, but have feedback from the bottom

Design Methodologies

"EXPLORER" METHOD:

- Typically used for new design ideas or research. It is useful in initial design and specification stages, and is often used when in " unfamiliar territory":
  1) Move in some direction; e.g. toward the library, telephone, domain expert's office, etc.
  2) Look at what you find there.
  3) Record what you find in your notebook.
  4) Analyze findings in terms of where you want to be.
  5) Use results of analysis to choose next direction.
  6) Back to 1) and continue exploring

Top-Down Application: Digital Design

SIMPLE DIGITAL STOPWATCH

Engineering requirements

- No more than two control buttons
- Implement Run, Stop and Reset
- Output a 16-bit binary number for seconds

Top-Down Design: Level 0

diagram and functional requirements are shown below.

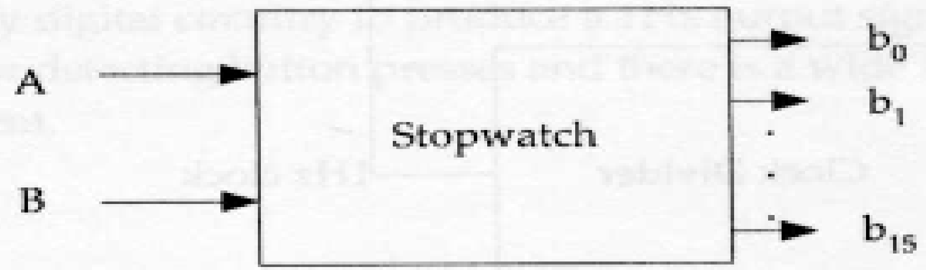


Figure 5.5 Level 0 digital stopwatch functionality.

Module	Stopwatch
Inputs	- A: Reset button signal. When the button is pushed, it provides a logic level high signal (5V) that resets the counter to zero. - B: Run/stop toggle signal. When the button is pushed, it provides a logic level high signal (5V) that toggles between run and stop modes.
Outputs	- b_{15}-b_0: 16-bit binary number that represents the number of seconds elapsed.
Functionality	The stopwatch counts the number of seconds after B is pushed when the system is in the Reset or Stop mode. When in Run mode and B is pushed, the stopwatch stops counting. A reset button push (A) will reset the output value of the counter to zero only when in Stop mode.

Top-down Design: Level 1

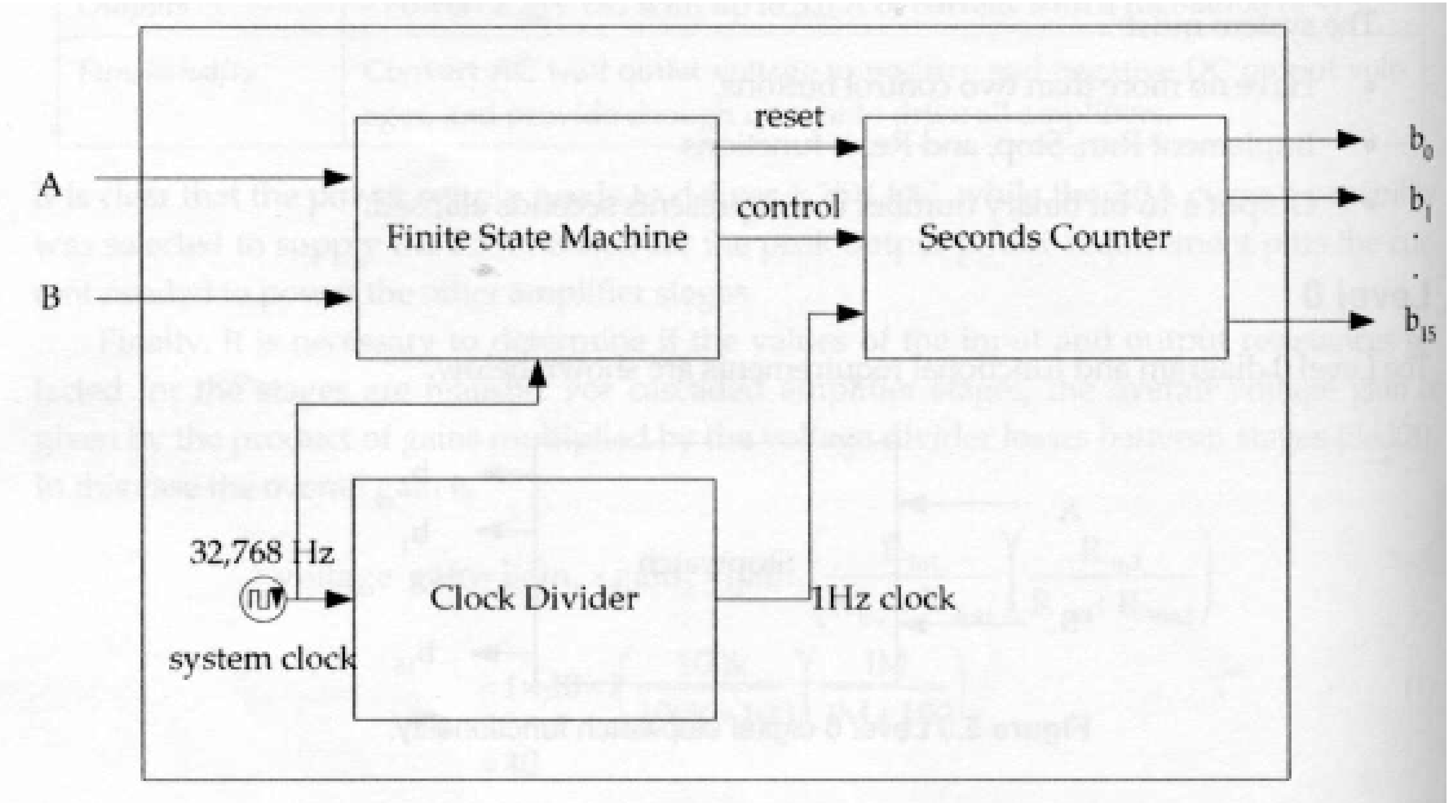


Figure 5.6 Level 1 design for the digital stopwatch.

Top-down Design: Level 1 (cont')

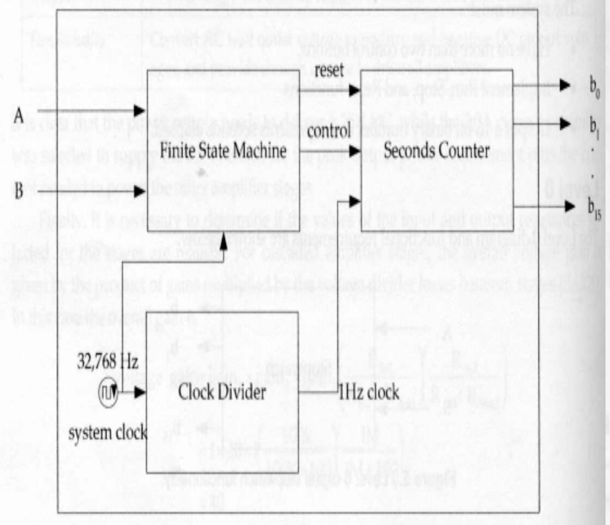
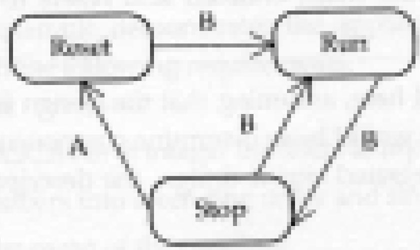


Figure 5.6 Level 1 design for the digital stopwatch.

Module	Finite State Machine
Inputs	- A: Signal to reset the counter. - B: Signal to toggle the stopwatch between run and stop modes. - Clock: 1Hz clock signal.
Outputs	- Reset: Signal to reset the counter to zero. - Control: Signal that enables or disables the counter.
Functionality	

Top-down Design: Level 1 (cont')

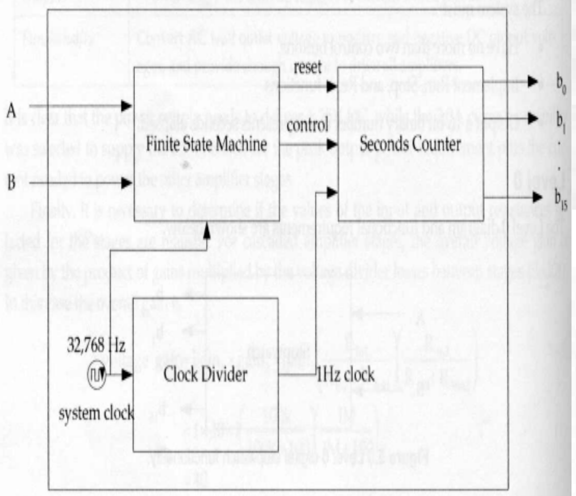


Figure 5.6 Level 1 design for the digital stopwatch.

Module	Clock Divider
Inputs	- System clock: 32,768Hz.
Outputs	- Internal clock: 1Hz clock for seconds elapsed.
Functionality	Divide the system clock by 32,768 to produce a 1Hz clock.

Module	Seconds Counter
Inputs	- Reset: Reset the counter to zero. - Control: Enable/disable the counter. - Clock: Increment the counter.
Outputs	- b_{15}-b_0: 16-bit binary representation of number of seconds elapsed.
Functionality	Count the seconds when enabled and resets to zero when reset signal enabled.

Design Group (Team)

- Engineering projects require diverse skills
- This creates a need for group (team) work

- Select members based on skills
  1. Technical
  2. Problem-solving
  3. Interpersonal

Design Group (Team)

- Develop decision making guidelines

  1. Decision by authority (leader)
  2. Expert Member
  3. Average member opinion
  4. Majority
  5. Consensus

Design Group (Team)

- Teams that spend time together tend to be successful teams
- Respect each other
  1. Listen actively
  2. Consider your response to others
  3. Constructively criticize ideas, not people
  4. Respect those not present
  5. Communicate your ideas effectively
  6. Manage conflict constructively

Design Group (Team)

- Hold effective meetings

1. Have an agenda
2. Show up prepared
3. Pay attention
4. Schedule time and place of next meeting
5. Summarize

- Assign tasks and responsibilities

Project Management

- **Work breakdown structure**
  - ✓ Hierarchical breakdown of tasks and deliverables need to complete project

- **Activity**
  1. Task - action to accomplish job
  2. Deliverable - e.g. circuit or report

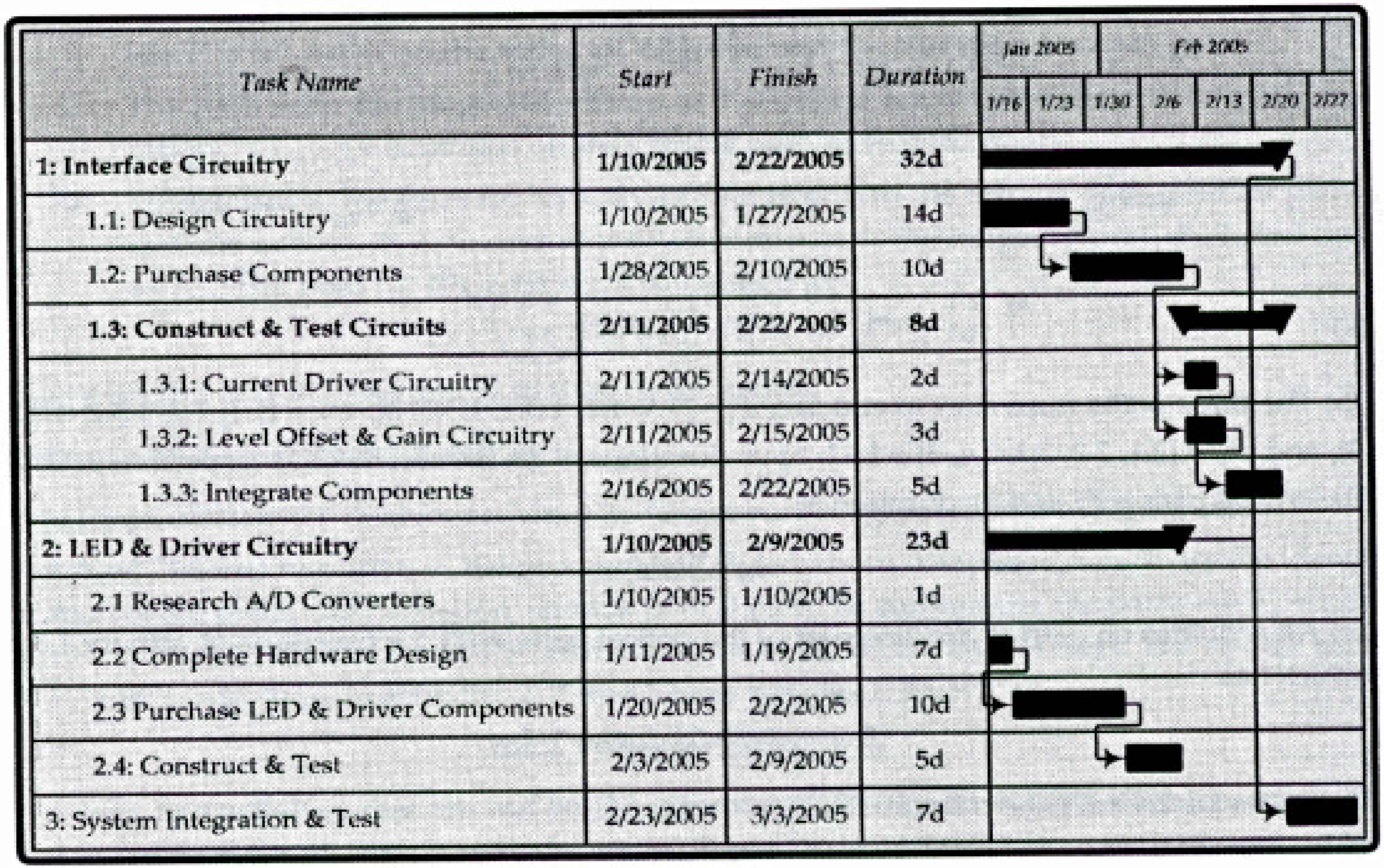
Project Management

- Define for each activity
  1. Work to be done
  2. Timeframe
  3. Resources needed
  4. Responsible person(s)
  5. Previous dependent activities
  6. Checkpoints/deliverables for monitoring progress

Table 10.1 Example work breakdown structure for the design of a temperature monitoring system.

ID	Activity	Description	Deliverables / Checkpoints	Duration (days)	People	Resources	Predecessors
1	**Interface Circuitry**						
1.1	Design Circuitry	Complete the detailed design and verify it in simulation.	• Circuit schematic • Simulation verification	14	Rob (1) Jana (1)	• PC • SPICE simulator	
1.2	Purchase Components		• Identify parts • Place order • Receive parts	10	Rob		1.1
1.3	**Construct & Test Circuits**	Build and test.					
1.3.1	Current Driver Circuitry	Test of circuit with sensing device.	• Test data • Measurement of linearity	2	Jana (1) Rob (2)	• Test bench • Thermometer	1.2
1.3.2	Level Offset & Gain Circuitry	Test of circuit with voltage inputs.	• Test data • Measurement of linearity	3	Rob (1) Jana (2)	• Test bench	1.2
1.3.3	Integrate Components	Integrate the current driver and offset circuits.	• Test data verifying functionality and linearity requirement	5	Rob (1) Jana (1)	• Test bench • Thermometer	1.3.1 1.3.2
2	**LED & Driver Circuitry**						
2.1	Research A/D Converters	Make selection of A/D converter.	• Identify types, cost, and performance • Identify two potential converters for purchase	1	Alex	• Internet	
2.2	Complete Hardware Design	Design conversion hardware.	• Circuit schematic • Simulation verification	7	Ryan (1) Alex (2)	• Digital circuit simulator	2.1
2.3	Purchase LED & Driver Components		• Identify parts • Place order • Receive parts	10	Rob		2.2
2.4	Construct & Test	Test with supply voltage input.	• Test data showing digital output vs. voltage inputs	5	Alex (1) Ryan (2)	• Test bench • Logic analyzer	2.3
3	System Integration & Test	Complete integration of front-end and LED driver circuitry.	• Test data demonstrating functionality from temp input to LED output • System linearity measurement	7	Alex (1) Rob (1) Jana (1) Ryan (1)	• Test bench • Digital logic analyzer • Thermometer	1.3.3 2.4 (or 1 and 2)

Schedule - Gantt Chart



Task Name	Start	Finish	Duration
1: Interface Circuitry	**1/10/2005**	**2/22/2005**	**32d**
1.1: Design Circuitry	1/10/2005	1/27/2005	14d
1.2: Purchase Components	1/28/2005	2/10/2005	10d
1.3: Construct & Test Circuits	**2/11/2005**	**2/22/2005**	**8d**
1.3.1: Current Driver Circuitry	2/11/2005	2/14/2005	2d
1.3.2: Level Offset & Gain Circuitry	2/11/2005	2/15/2005	3d
1.3.3: Integrate Components	2/16/2005	2/22/2005	5d
2: LED & Driver Circuitry	**1/10/2005**	**2/9/2005**	**23d**
2.1 Research A/D Converters	1/10/2005	1/10/2005	1d
2.2 Complete Hardware Design	1/11/2005	1/19/2005	7d
2.3 Purchase LED & Driver Components	1/20/2005	2/2/2005	10d
2.4: Construct & Test	2/3/2005	2/9/2005	5d
3: System Integration & Test	2/23/2005	3/3/2005	7d

Figure 10.3 Gantt chart for the temperature display project created using Microsoft Visio™.

Project Management

- Guidelines
  - Project plan after design plan complete
  - Double time estimates and add 10%
  - Assign a lot of integration and test time
  - Remember lead times for parts ordering
  - Assign tasks based on skills and interests
  - Track progress versus plan
  - Plans change

Project Communication

Focus on needs of specific audience

- **Who?**
  - ➢ level of knowledge
  - ➢ their motivation - needs

- **Why?**
  - ➢ to persuade
  - ➢ to inform

Project Proposal

- **One goal is to sell idea, be persuasive**
  - In industry the proposal will show:
    1. Product is useful for someone for something
    2. The design will work, it will solve the problem
    3. Will meet the specified constraints
  - Additionally, in Senior Design, the proposal should show:
    1. You are learning something new
    2. Sufficiently complex
    3. Apply previously learned ECE knowledge

Project Proposal Format

- **Second goal is to inform**
  1) *Title page* – project title, names, date, group number.
  2) *Table of Contents*, with page numbers.
  3) *Introduction*
  4) *Problem Analysis*
  5) *Requirements Specification*
  6) *Preliminary Design.* Include a block diagram – the more detailed the better. Will help with the scheduling and task assignment
  7) *Preliminary Schedule* (see Figure 10.3, Gantt chart)
  8) *Conclusion* - summarize why this will be a great senior project.
  9) *References* - any references used in proposal development

Oral Presentations

- **Structure**
  1. Intro: Tell them what you will tell them
     - Introduce group and project
     - Overview and background
  2. Body: Tell them
     - Use top-down approach
     - Support main points
  3. Conclusion: Tell them what you told them
     - Summarize and emphasize main points

Oral Presentations

- Tips
  - Prepare - practice, practice, practice
  - Eye contact with entire audience
  - Avoid too much information
  - Meet time constraints
  - Look and act professionally
  - Use visuals effectively

Oral Presentations

- Slides
  - ➢ Use a large font, 24 pt or more
  - ➢ Avoid more than 4 or 5 bullets per page
  - ➢ Avoid fancy graphics that add no value
  - ➢ Group slides for major points (top-down)
  - ➢ Avoid reading slides

Presentations

- Your presentation should be 10 to 15 minutes for a project engineering team (5-10 min for a team of 2). Due to the limited class time you will be cutoff if you exceed the upper limit.
  - Professionalism - appearance, manner, visual aids
  - Clarity - Can we understand what your design is about?
  - Organization - Is your talk well-organized? Does it follow a logical progression? Is it presented in a top-down manner?
  - Completeness - Are all the parts there? Did you provide a good introduction? Clear, positive conclusions and/or summary? etc...
  - Communication - Did you maintain eye contact with the entire audience? Did they understand you ? etc...
  - Time Limits - Did you stay within the specified time limits?
  - Questions - Were you successful at fielding questions after you presentation? Are you knowledgeable on the subject matter ?

Presentations

- Evaluation and Grade Sheet

Good....................OK.......................Poor

	4	3	2	1	0
Introduction	___	___	___	___	___
Clarity	___	___	___	___	___
Organization	___	___	___	___	___
Professionalism	___	___	___	___	___
Communication	___	___	___	___	___
Conclusion	___	___	___	___	___
Time limits	___	___	___	___	___
Completeness	___	___	___	___	___
Understanding	___	___	___	___	___
Questions	___	___	___	___	___

Summary

- Engineering design is an iterative process.
- Design problems are open-ended with many potential solutions.
- Design processes represent best practices for realizing a system.
- Design processes may be prescriptive or descriptive.

Assignment No. 3

- Make a report about one engineering design of interest that can be used in your home place or country as a whole. Apply the design process you learned. Write your report in 3 to 4 pages using A4 size paper.

Lecture 4
Engineering Ethics

C.M. Pascual
Professor, CACE

Topics

1. What is engineering ethics?
2. Fundamental principles of engineering ethics
3. General rules (Fundamental Canon)

The Goal

The lecture will develop a framework on which professional and ethical issues can be analyzed, and build up an awareness of various views of ethical issues as well as professionals ethical rights and responsibilities.

The Goal

- Teach fundamental principles and canons of engineering ethics
  - Clarification of nature of ethics
  - Process to resolve ethical dilemmas
  - NCEES Model Rules of Professional Conduct
  - ASME Code of Ethics
- Provide case studies to examine issues and resolve problems from a second person perspective

Outline

- Ethic and professionalism
  - Scope, responsibility, professionalism
- Moral reasoning and code of ethics Professionalism
  - Ethical dilemma, moral choices,
  - Code of Professional ethics
  - Moral framework
  - Stages of Moral Development
  - Utilitiarism, duty ethics, vitue ethics, right ethics

Course Outline (Continued)

Engineering as social experimentation

- ❖ Engineering experimentation
- ❖ Engineers as responsible experimenters: Consciousness, Comprehensive perspectives, Moral autonomy , Accountability,

❖ Commitment to safety

- ❖ Safety and risk
- ❖ Assessing and reducing risk

Course Outline (continued)

- Workplace responsibility and right
  - Teamwork
  - Confidential and Conflict of interest
  - Rights of engineers, Whistleblowing
- Honesty
  - Thrutfulness, truthworthiness, integrity
  - Consulting engineers
  - Expert witness

Course Outline (continued)

- Environmental ethics
  - Engineering, Ecology and Economics
  - Ethical frameworks
- Global Issues
  - Multinational corporations
  - Computer ethics and the internet
  - Weapon development

Course Outline (continued)

- Engineers and technological concept
  - Cautious optimism
  - Moral leadership
- Case study (group assignment)
  - Ford pinto
  - DC 10
  - Challenger
  - Bhopal
  - Etc

Morality and Ethics

- Concerns the goodness of voluntary human conduct that affects the self or other living things
- Morality (Latin *mores*) usually refers to any aspect of human action
- Ethics (Greek *ethos*) commonly refers only to professional behavior

The Nature of Ethics

- Ethics is generally concerned with rules or guidelines for morals and/or socially approved conduct
- Ethical standards generally apply to conduct that can or does have a substantial effect on people's lives

Why study ethics?

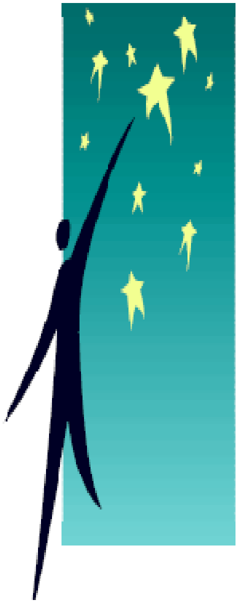
- When students enter the professional world, they will be expected to follow an explicit or implicit ethical code.
- To responsibly confront moral issues raised by technological activity
- How to deal with ethical dilemmas in their professional lives?
- To achieve moral autonomy

Moral Dilemmas

- Situations in which two or more moral obligations, duties, rights, or ideals come into conflict.
- To resolve we must identify the factors, gather facts, rank moral considerations, consider alternative courses of actions, and arrive at a judgement.

What Is Ethics?

Josephson Institute of Ethics



Ethics refers to standards of conduct . . . that indicate how one should behave based on principles of right and wrong.
As a practical matter, ethics is about how we meet the challenge of doing the right thing

What is Engineering Ethics?

- The study of moral issues and decisions confronting individuals engaged in engineering.
- The study of related questions about the moral ideas, character, policies, and relationships of people and organizations involved in technical activity.

Ethos (Greek) = mores (Latin) meaning "customs"

Stages of Moral Development

- **Pre-conventional Level**
  Whatever benefits oneself or avoids punishment (*Obey speed laws*)
- **Conventional Level**
  Uncritical acceptance of society's rules (*Nazi's holocaust; apartheid in South Africa*)
- **Post-conventional Level**
  Moral autonomy (*to stand up what one believes)*

Moral Autonomy

- Autonomous individuals think for themselves and do not assume that customs are always right.
- They seek to reason and live by general principles.
- Their motivation is to do what is morally reasonable for its own sake, maintaining integrity, self-respect, and respect for others.

Examples of Moral Autonomy:

- Casius Clay (Mohammed Ali) and the

Vietnam War

- Mahatma Ghandi in India -- got independence by peaceful means
- Rev. Martin Luther King, Jr.-- Civil Rights

An example:

- "One who breaks an unjust law must do so openly, lovingly, and with a willingness to accept the penalty. I submit that an individual who breaks a law that conscience tells him is unjust and willingly accepts the penalty… is in reality expressing the highest respect for the law." *Rev. Martin Luther King, Jr.* in **Letter from a Birmingham Jail**, 1963.

Law vs. Ethics

- LAW
  - Creates rules to guide conduct
  - Balances competing values
  - Punishes conduct that is "illegal" through formal structures

- ETHICS
  - Offers guidance on conduct
  - Addresses situations in which competing values clash
  - Incentives and disincentives may be created by "group" (formal or informal)

Is “legal” the same as “ethical?”

- YES:
  - Law defines duties, rights, “allowable conduct.”
  - Compliance approach to business ethics: fulfill legally recognized duties, and don’t go further.
- NO:
  - Law does not address all ethical dilemmas
  - Legal duties may not meet standard of ethical conduct
  - “Beyond Compliance” approach: fulfill legally recognized duties, but don’t stop there.

In case of conflicts, it’s generally held that legal standards must give way to ethical standards

The Existence of Right and Wrong

- **Principle:** *Certain aspects of right and wrong exist objectively, independent of culture or personal opinion.*
- Accepting this principle is essential for ethics to discern an objective reality rather than just define a subjective standard.

The Four Main Virtues

- **Prudence** (mind): to think about a moral problem clearly and completely
- **Temperance** (emotions): control attraction to positive emotions
- **Fortitude** (emotions): control aversion for negative emotions
- **Justice** (will): choose according to truth and fairness.

A fundamental principle of morality:

- *People should try insofar as possible to continue to progress in the moral life*

- *The obligation to avoid what is bad outweighs the obligation to do what is good.*

- Or, the end does not justify the means.

Moral Responsibility

- Morality concerns the goodness of voluntary human activity that impacts the self or other living beings.
- Assuming we have not deliberately allowed ourselves to remain *ignorant, powerless,* or *indifferent*, we have complete moral responsibility for what we do with adequate *knowledge, freedom,* and *approval*.

Professional Ethics

- What is a “profession”?
- What is “ethics”?
- What is “professional ethics”?
- Ethical theories
- Thinking about professional ethics
- Professional values
- Codes of Ethics

Do you agree?

- It is always wrong to intentionally take an innocent life?
- The right course of action is to weigh the consequences of action and choose the action that leads to the greatest good for the greatest number?

Two Valid Moral Positions

- The first is “Kantianism”
- Kant: Right or wrong regardless of consequences
- The second is “Utilitarianism”
- Utilitarianism: Right or wrong depending on consequences
- Most people agree with both positions

Dilemma

- The hijacked plane with 200 people is approaching a building with 50,000 people
- Vote! Will you shoot down the plane?
- You cannot subscribe to both principles in the case.
- A true moral dilemma
- Which position has the greatest weight in the circumstances?

Orientation

Aim to show several different ways to think through a problem in professional ethics, rather than merely describe what professionals say are their problems (sociology of ethics).

"Profession"
"Ethics"
"Professional Ethics"

Profession

- All professions are occupations, but not all occupations are professions
- Can take a broad or narrow view of what is a "profession"
- A "self-regulated occupational group capable of legally prohibiting others (including incompetent or unethical members) from practising" is a narrow view

Profession

- Group identity
- Shared education, training -- requirements for admission
- Special uncommon knowledge
- Knowledge used in the service of others… positive social need
- Involves individual judgment, (some) autonomy in decisions
- Adherence to certain values
- Penalties for substandard performance

Profession

- Matter of degree … there are many “emerging professions”.
- Obstacle in the way of the OHS professional is the diverse nature of practice with competing co-professionals.

You are not a professional until you are a member of a group of colleagues who have articulated a set of standards and values and can enforce them, at the very least, by exclusion from the group.

What is a professional?

- Possesses specialized knowledge and skills
- Belongs to and abides by the standards of a society
- Serves an important aspect of the public good

What is a professional engineer?

- ❖ Has a bachelor’s degree in engineering from an accredited school
- ❖ Performs engineering work
- ❖ Is a registered P.E. (in some countries)
- ❖ Acts in a morally responsible way while practicing engineering

Other definitions

- Must be independent
- Must serve employer
- Must satisfy two general criteria
  (1) Attain high standards of achievement in education, job performance, and creativity.
  (2) Accept moral responsibilities to the public, their employers, clients, colleagues, and subordinates.

“Professionalism”

- Skill, competency in work
- Relational element – work will be beneficial to others
- Work itself doesn’t have moral status
- Execution of work has moral status

Recognizing when We’re in the Realm of Ethics
Watch the language:
Right and wrong -- Actions
Good and bad -- Motives, methods, goals

The Engineering Profession

- How we view ourselves:
  - Problem-solvers
  - Engineering is enjoyable; *esprit de corps*
  - Engineering benefits people, provides a public service
  - Engineering provides the most freedom of all professions (Florman, 1976)
  - Engineering is an honorable profession

The Engineering Profession

- How the public views engineering:
  - The Engineer’s Role
    - Engineers as Utilitarians
    - Engineers as Positivists
    - Applied Physical Scientists
  - This role does not mesh well with an overarching “social science” bias of the public.

The Engineering Profession

- Rational, pragmatic, logical and systematic approaches to problem solving tend to alienate the engineer from the public
  - Only a 50% “Very High” or “High” rating on honesty
    - Consistently behind medical field and teachers
    - A public relations problem, not an ethics issue per se.
    - “Best Practices” to include applied social science

Professional Ethics

- Purpose… Helps professional decide when faced with a problem that raises a moral issue
- Complexity … Can be many people, with many issues involved … may be involved history to the issues … may be an issue WHO decides, not just WHAT decided.

Why the Interest in Professional Ethics?

- As occupations become more specialized, the ethical issues become more specialized
- Professional societies have increased efforts to establish ethical codes to guide members
- Increasing public scrutiny, lack of traditional deference
- Regulatory oversight, public protection

What is Engineering Ethics*

- The study of the moral issues and decisions confronting individuals and organizations engaged in engineering
- The study of related questions about the moral ideals, character, policies, and relationships of people and corporations involved in technological activity.

* from Martin. M. & Schinzinger, R. Ethics in Engineering (3rd Ed.) (New York: McGraw-Hill, 1996, pp. 2-3.

Ethics and Engineering

- Where the ethical issues can arise:
  - Conceptualization, Design, Testing, Manufacturing, Sales, Service
  - Supervision and Project Teams
    - Project timelines and budgets
    - Expectations, opinions, or judgments
  - Products: Unsafe or Less than Useful
    - Designed for obsolescence
    - Inferior materials or components
    - Unforeseen harmful effects to society

Ethics and Engineering

- Other fields where ethics are critical
  - Medical Ethics, Legal Ethics
  - Business Ethics (closest to Engineering Ethics)
  - Scientific Ethics
- An “applied ethics” domain (rather than a theoretical analysis of philosophy)
- Engineering occurs at the confluence of *technology*, *social science*, and *business*
  - Engineering is done by people and for people
  - Engineers’ decisions have a impact on all three areas in the confluence
  - The public nature of an engineer’s work ensures that ethics will always play a role

Ethics and Engineering

- **Impacts of an engineer's ethical decisions:**
  - The Products & Services (safety and utility)
  - The Company and its Stockholders
  - The Public and Society (benefits to the people)
  - Environment (Earth and beyond)
  - The Profession (how the public views it)
  - The Law (how legislation affects the profession and industry)
  - Personal Position (job, internal moral conflict)

Ethics and Engineering

- Typically, good ethical decisions…
  - …may be just that: “good,” but rarely “great” or “ideal”
  - …will not always be in the best interest (irrespective of the timeline) of all stakeholders
  - …are not automatic but require thought, consideration, evaluation, and communication (much like the “design process”)

Ethics and Morality

- Morality – making choices with reasons
- Ethics – the study of HOW the choices are made, ie “ethics is the study of morality”
- Often use “ethics” and “morality” interchangeably

General vs Professional, Morality and Ethics

- General Ethics – individual as member of community, broader range of issues, “top down” principles
- Professional Ethics – moral expectations specific to the occupational group, tend to focus on concrete “bottom up” cases
- Professional Morality – what we do in our occupational lives
- Professional Ethics – the study of what we do in our professional lives

Ethics and Law

- Law – the authority is external
- Ethics – the authority is internal

- Much of law, but not all, is based in morality
- Sometimes law is unethical
- Much of what is ethical is unaddressed by legal rules

Professional Ethics and Law

- There is a moral duty to obey the law (with some caveats)
- Professional ethics covers more issues than the law
- One can be unethical without behaving illegally
- Rare – ethically must resist the law

Professional Ethics and Law

Be very careful not to embark in an exercise in ethical analysis when there is a clear legal rule in the situation that trumps the entire process of ethical analysis.

Be very careful not to assume that there is a legal rule for every situation. Often the gaps between legal rules require one to switch to an ethical analysis.

Ethics

- Descriptive ethics – “What IS”
- Prescriptive ethics – “What OUGHT to be”
- We do not seek to study professional ethics as a sociologist would, but to assist with choices about what one ought to do.
- 2002 British study by Burgess and Mullen: 77% of hygienists had witnessed ethical misconduct by colleagues within last 5 years.

Descriptive Ethics
Burgess and Mullen study

Most common cases:

- Plagiarism
- Confidentiality of data
- Faked data
- Criticizing colleagues for gain
- Holding back, disguising data
- Destruction of data
- Not reporting incident deliberately

Obligation to Society

- “Clean Hands” Rule
  7. “Engineers shall not enter business ventures or permit their names or their firm’s names to be used by any persons or firm which is engaging in dishonest, fraudulent, or illegal business practice”
- Final Obligation to Society
  8. “Engineers who have knowledge of possible violation of any of the rules listed in this and the following two parts shall provide pertinent information and assist the state board in reaching final determination of the possible violation”

Engineer’s Obligation to Employers and Clients

- Professional competence
  1. “Engineers shall not undertake technical assignments for which they are not qualified”
  2. “Engineers shall approve or seal only those plans or designs that deal with subjects in which they are competent and which have been prepared under their direct control and supervision”

Engineer’s Obligation to Employers and Clients

- Professional competence
  1. “Engineers shall not undertake technical assignments for which they are not qualified”
  2. “Engineers shall approve or seal only those plans or designs that deal with subjects in which they are competent and which have been prepared under their direct control and supervision”

Engineer’s Obligation to Employers and Clients

- The Validity of Approvals

“Engineers may coordinate an entire project provided that each design component is signed or sealed by the engineer responsible for that design component”

Engineer’s Obligation to Employers and Clients

- Confidentiality Requirement

“Engineers shall not reveal professional information without the employer’s or client’s prior consent except as authorized or required by law”

Engineer’s Obligation to Employers and Clients

❖ Conflict of Interest

1. “Engineers shall not solicit or accept direct or indirect considerations, financial or otherwise, from contractors, their agents, or other parties while performing work for employers or clients”

2. “Engineers shall disclose to their employers or clients potential conflicts of interest or any other circumstances that could influence or appear to influence their professional judgment or their service quality”

Engineer’s Obligation to Employers and Clients

- Full Disclosure

“An engineer shall not accept financial or other compensation from more than one party for services rendered on one project unless the details are fully disclosed and agreed by all parties”

Engineer's Obligation to Employers and Clients

- Government Conflicts of Interest

"To avoid conflicts of interest, engineers shall not solicit or accept a professional contract from a governmental body on which a principal or officer of their firm serves as a member. An engineer who is a principal or employee of a private firm and who serves as a member of a governmental body shall not participate in decisions relating to the professional services solicited or provided by the firm to the governmental body"

Engineer’s Obligations to Other Engineers

❖ Obligation to Potential Employers

“Engineers shall not misrepresent or permit misrepresentation of their or any of their associate’s academic or professional qualifications. They shall not misrepresent their level of responsibility or the complexity of prior assignments. Pertinent facts relating to employers, employees, associates, joint ventures, or past accomplishments shall not be misrepresented when soliciting employment or business”

Engineer’s Obligations to Other Engineers

- Conflicts of Interest

“Engineers shall not directly or indirectly give, solicit, or receive any gift or commission, or other valuable consideration, in order to obtain work, and shall not make contribution to any political body with intent of influencing the award of contract by governmental body”

Engineer's Obligations to Other Engineers

❖ Reputations of Other Engineers

1. "Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputations, prospects, practice or employment of other engineers, nor indiscriminately criticize the work of other engineers"
2. Criticize cautiously and objectively with respect to the person's professional status

Engineering Ethics and Legal Issues

- Contract Law

Mutual agreement between two or more parties to engage in transaction which provides benefits to each of them

1. Mutual consent
2. Offer and acceptance
3. Consideration

Engineering Ethics and Legal Issues

❖ Other Contract Issues

1. Legally enforceable agreement requires a definite promise by each party to do something specific
2. Some benefit received that each did not have before
3. Does not have to be in writing to be valid

Engineering Ethics and Legal Issues

❖ Breach of Contract

An actual violation of the terms in the contract must occur

1. Items not supplied, supplied but of substandard quality, or not supplied until long after a deadline
2. Party required to provide an equivalent value previously offered
3. Inability to fulfill contract is under ethical and legal imperative to do everything possible to provide equivalent value to other party

Engineering Ethics and Legal Issues

- The Letter vs. Spirit of the Law

"Read between the lines" in terms of the intent of those documents as understood by those who formulated them"

ASME Code of Ethics of Engineers – Fundamental Principles

Engineers uphold and advance the integrity, honor, and dignity of the Engineering profession by:

- using their knowledge and skill for the enhancement of human welfare;
- being honest and impartial, and serving with fidelity the public, their employers and clients,
- striving to increase the competence and prestige of the engineering profession.

ASME Code of Ethics of Engineers – Fundamental Canons (1)

- Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.
- Engineers shall perform services only in the areas of their competence.
- Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional development of those engineers under their supervision.

ASME Code of Ethics of Engineers – Fundamental Canons (2)

- Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.
- Engineers shall build their professional reputations on the merit of their services and shall not compete unfairly with others.
- Engineers shall associate only with reputable persons or organizations.
- Engineers shall issue public statements only in an objective and truthful manner.

Group Exercise

- Each group is given 10 minutes to discuss and prepare solutions in Powerpoint, and 10 minutes for presentation to class and Q&A
  - Group 1: Case 1 (15.3)
  - Group 2: Case 2 (15.4)
  - Group 3: Case 3 (15.6)
  - Group 4: Case 4 (15.7)
- Cases are designed as problems for you, so seek resolutions that you personally can live with.

Case 1

Newly hired as a production engineer, you find a potential problem on the shop floor: workers are routinely ignoring some of the government mandated safety regulations governing the presses and stamping machines.

The workers override the safety features such as guards designed to make it impossible to insert a hand or arm into a machine. Or they rig up "convenience" controls so they can operate a machine while close to it, instead of using approved safety switches, etc., which requires more movement or operational steps. Their reason (or excuse) is that if the safety features were strictly followed then production would be very difficult, tiring and inefficient. They feel that their shortcut still provides adequately safe operation with improved efficiency and worker satisfaction.

Should you immediately insist on full compliance with all the safety regulations, or do the workers have enough of a case so that you would be tempted to ignore the safety violations? And if you're tempted to ignore the violations, how would you justify doing so to your boss?

Also, how much weight should you give to the workers' clear preference for not following the regulations: ethically, can safety standards be relaxed if those to whom they apply want them to be relaxed?

Case 2

You and an engineer colleague work closely on designing and implementing procedures for the proper disposal of various waste materials in an industrial plant. He is responsible for liquid wastes, which are discharged into local rivers.

During ongoing discussions with your colleague, you notice that he is habitually allowing levels of some toxic liquid waste chemicals, which are slightly higher than levels permitted by the law of those chemicals. You tell him that you have noticed this, but he replies that, since the levels are only slightly above the legal limits, any ethical or safety issues are trivial in this case, and not worth the trouble and expense to correct them.

Do you agree with your colleague? If not, should you attempt to get him to correct the excess levels, or is this none of your business since it is he rather than you who is responsible for liquid wastes?

If he refuses to correct the problems, should you report this to your boss or higher management? And if no one in your company will do anything about the problem, should you be prepared to go over their heads and report the problem directly to government inspectors or regulators? Or should one do that only in a case where a much more serious risk to public health and safety involved?

Case 3

Your company has for some time supplied prefabricated wall sections, which you designed, to construction companies. Suddenly one day a new idea occurs to you about how these might be fabricated more cheaply using composites of recycled waste materials.

Pilot runs for the new fabrication technique are very successful, so it is decided to entirely switch over to the new technique on all future production runs for the prefabricated sections. But there are managerial debates about how, or even whether, to inform the customers about the fabrication changes.

The supply contracts were written with specifications and functional terms, so that love bearing capacities and longevity, etc., of the wall sections were specified, but no specific materials or fabrication techniques were identified in the contracts. Thus it would be possible to make the changeover without any violation of the ongoing contracts with the customers.

On the other hand, since there is significant cost savings in the new fabrication method, does your company have an ethical obligation to inform the customers of this, and perhaps even to renegotiate supply at reduced cost, so that the customers also share in benefits of the new technique? More specifically, do you have any special duty, as a professional engineer and designer of the new technique, to be an advocate in your company for the position that customers should be fully informed of the new technique and the associated cost savings?

Case 4

Your company manufactures security systems. Up to now these have raised few ethical problems, since your products were confined to traditional forms of security, using armed guards, locks, reinforced alloys which are hard to cut or drill, and similar methods.

However, as a design engineer you realize that this modern technology much more comprehensive security packages could be provided to your customers. These could also include extensive video and audio surveillance equipment, along with biometric monitoring devices of employees or other personnel seeking entry to secure areas which would make use of highly personal data such as a person's fingerprints, or retinal or voice patterns.

But there is a problem to be considered. A literature search reveals that there are many ethical concerns about the collection and use of such personal data. For example, these high-tech forms of surveillance could easily become a form of spying, carried out without the knowledge of employees and violating their privacy. Or the data collected for security reasons could easily be sold or otherwise used outside legitimate workplace contexts by unscrupulous customers of your surveillance systems.

Your boss wants you to include as much of this advanced technology as possible in future systems, because customers like these new features and are willing to pay well for them.

However, you are concerned about the ethical issues involved in making these new technologies available. As an engineer, do you have any ethical responsibility to not include any such ethically questionable technologies in products which you design and sell, or to include them only in forms which are difficult to misuse? Or is the misuse of such technologies an ethical problem only for the customers who are buying your equipment, rather than it being your ethical responsibility as an engineer?

Descriptive Ethics

Patricia Logan 2001, USA. Reported reasons for misbehavior, hygienists:

- Economic pressure
- Transition from employee to consultant results in compromises
- Working in foreign countries
- Lack of legal standards
- Working on contingency basis
- Decrease in job security

Descriptive to Prescriptive

Two very different ways of reasoning. Descriptive, or scientific, studies of professional ethics help us identify issues that need to be included in Code of Ethics and in educational programs. Gives us our “case studies”.

Prescriptive Ethics

- “What OUGHT to be”
- The words used are different… good-bad, right-wrong, just-unjust
- Thought processes use values, goods, virtues, rules, ethical theories, moral reasons, moral explanations, and moral decisions.

Short course in
Engineering Ethics
(Presented as a part of ECE 4242)

Spring 2009

Outline

- **PART 1**: Informative (lecture 1)
  - Reason for studying engineering ethics
  - Examples of ethical problems in engineering
- **PART 2**: Educational (lecture 2)
  - Basic concepts in engineering ethics
  - Code of ethics for electrical and computer engineers
- **PART 3**: Test (lecture 3)
  - Students will be tested on material presented in parts 1 and 2

Engineering ethics – introductory remarks

- Engineering ethics
  - Applied ethics
  - Focuses on set of standards that cover engineers' responsibility to the public, clients, employers and profession
- Engineering – one of fundamental human activities
  - Large social impact and significant responsibility
  - Engineers are often placed into conflict situations – they need to be able to resolve conflicts in ethical manner
- **ABET** - recognized accreditor for college and university programs in applied science, computing, engineering, and technology
  - Requirement for teaching engineering ethics
  - Goal – preparation of students for ethical challenges in technology dominated world

Examples of ethical problems in engineering

- Presentation of two videos
  - NSF series of ethical problems in engineering
    - Point 1: note the nature of conflicts that engineers face
    - Point 2: acting ethically is a great challenge in an environment that is not supportive
  - Ethics in engineering – Challenger case
    - Point 1: engineering and business ethics
    - Point 2: ethical issues and engineer's career

Engineering codes of ethics

- Guidelines and principles for evaluation of ethical conflicts
- Not laws but often basis for laws
- Developed for most engineering disciplines
- Formally accepted by professional engineers
- ECE engineering covered by
  - NSPE Code of Ethics (Handout 1)
  - IEEE Code of Ethics (Handout 2)

NSPE – code of ethics

- NSPE – National Society of Professional Engineers
- Professional engineer (PE)
  - Hold professional license, member of NSPE
  - Providing professional services to public, clients or government
- PE are governed by statute and have very formal code of ethics
- NSPE published first version of code of ethics in 1952
- Several revisions until present form
- Consists of
  - Fundamental cannons = fundamental principles
  - Rules of practice = practical implementation of cannons
  - Professional obligations = specifies guidelines for professional conduct
- NSPE provides Board of Ethical Review to the members

NSPE – code of ethics (2)

- Fundamental cannons
  1. Hold paramount the safety, health and welfare of public
  2. Perform services in area of competency
  3. Issue public statement in an objective and truthful manner
  4. Act for employer or client as a faithful agent and trustees
  5. Avoid deceptive acts
  6. Conduct themselves honorably, responsibly and lawfully so as to enhance honor, reputation and usefulness of the profession

Based upon these fundamental cannons, various engineering societies develop their own (usually more specific) codes of ethics

IEEE – code of ethics

- IEEE - Institute of Electrical and Electronics Engineers
- Formed in 1963 as a merger of AIEE (American Institute of Electrical Engineers) and IRA (Institute of Radio Engineers)
- Worlds largest professional/technical organization for advancement of technology
- Majority of IEEE societies are in areas of ECE
- IEEE membership requires adherence to

IEEE – code of ethics

1. to accept responsibility in making decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;
2. to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;
3. to be honest and realistic in stating claims or estimates based on available data;
4. to reject bribery in all its forms;
5. to improve the understanding of technology, its appropriate application, and potential consequences
6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
8. to treat fairly all persons regardless of such factors as race, religion, gender, disability, age, or national origin;
9. to avoid injuring others, their property, reputation, or employment by false or malicious action;
10. to assist colleagues and co-workers in their professional development and to support them in following this code of ethics

Note 1: Maroon – overlap with NSPE fundamental cannons

Note 2: Code is broader than NSPE

Some cases of ethical decisions facing engineers

- Acknowledging mistakes (IEEE CoE – Cannon 7)
- Conflict of interest (IEE CoE – Cannon 2)
- Safety of products (IEEE CoE – Cannon 1)
- Environmental safety (IEEE CoE – Cannon 1)
- Responsibility arising from what others do (IEEE CoE Cannon 10)
- Discrimination in the work place (IEEE CoE Cannon 8)
- Whistle blowing (IEEE CoE Cannons 1, 2, 3,

Big picture

- Codes of ethics are not a law
- Ethical behavior is not always protected by law
- Frequently ethical behavior may be perceived as disloyalty
- Many companies realize that ethical behavior is essential for their long term prosperity
- Ethically aware companies provide
  - Provide help to employees facing ethical conflicts

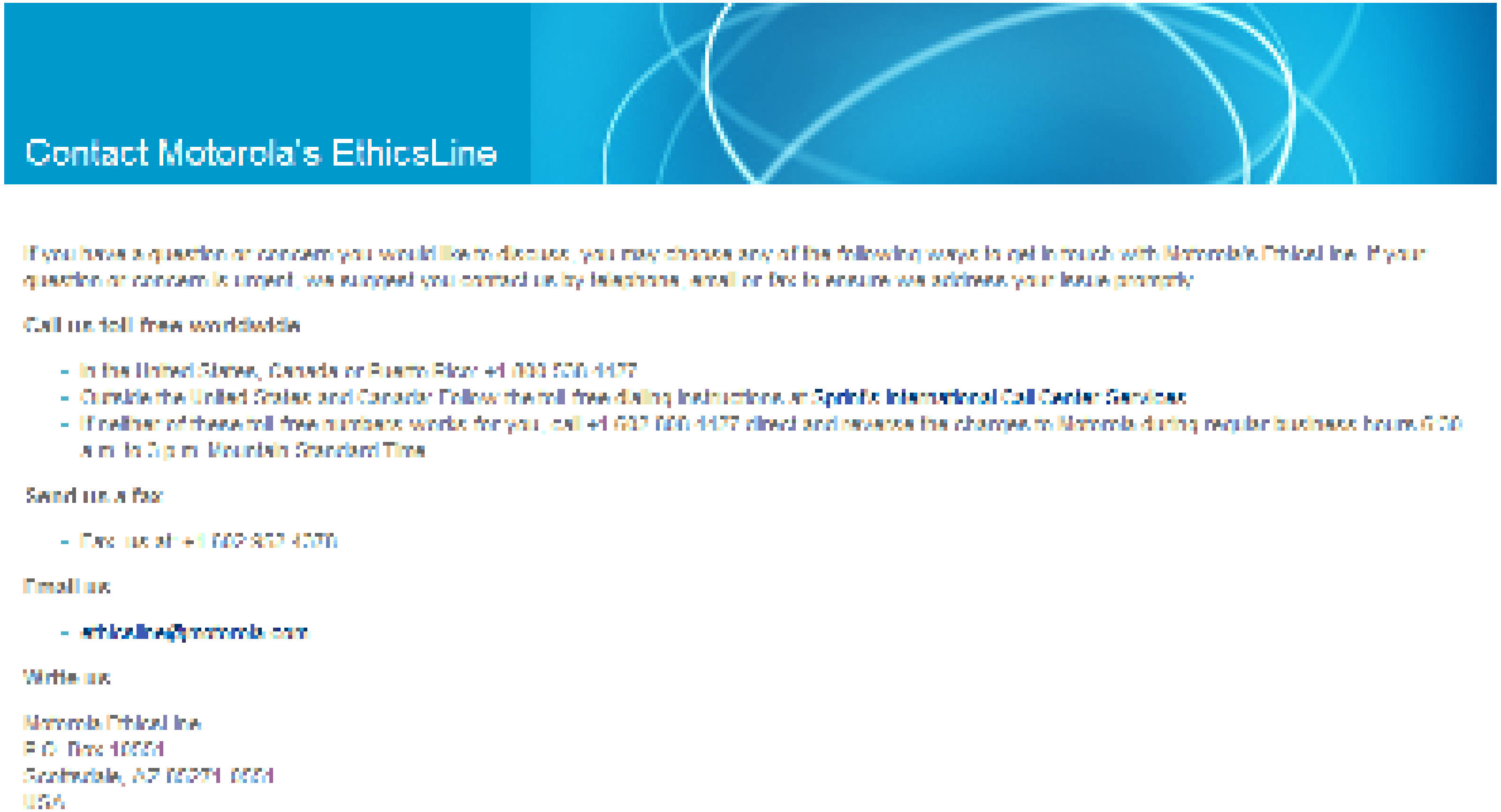
Example 1: TI Ethics Quick Test

TEXAS INSTRUMENTS

- Is the action legal?
- Does it comply with our values?
- If you do it, will you feel bad?
- How will it look in the newspaper?
- If you know it's wrong, don't do it!
- If you're not sure, ask.
- Keep asking until you get an answer.

This information is provided to TI employees on a business-card size mini-pamphlet to carry with them. For copies of the card or further information, contact the TI Ethics Office at 1-800-33-ETHIC.

Example 2: Motorola Ethics Line



Contact Motorola's EthicsLine

If you have a question or concern you would like to discuss, you may choose any of the following ways to get in touch with Motorola's EthicsLine. If your question or concern is urgent, we suggest you contact us by telephone, email or fax to ensure we address your issue promptly.

Call us toll free worldwide

- In the United States, Canada or Puerto Rico: +1 800 [illegible]
- Outside the United States and Canada: Follow the toll free dialing instructions at Sprint's International Call Center Services
- If neither of these toll free numbers works for you, call +1 602 [illegible] direct and reverse the charges to Motorola during regular business hours 6:30 a.m. to 3 p.m. Mountain Standard Time

Send us a fax

- Fax us at +1 602 [illegible]

Email us

- ethicsline@motorola.com

Write us

Motorola EthicsLine
P.O. Box [illegible]
Scottsdale, AZ [illegible]
USA

In preparation for test

- Memorize six fundamental cannons of NSPE code of ethics
- Be able to explain ethical decisions given in Slide 10
- Be able to give examples for each of the ethical decisions in Slide 10
- Practice your ethical judgment by evaluation some of case studies provided at

http://ethics.tamu.edu/pritchar/an-intro.htm

3. General rules (Fundamental Canon)

Employee Rights

 Dr. B. C. Paul

Note - This lecture draws in part on materials from Ronald B. Sandler on Professional Ethics and Wrongful Discharge

Employment Arrangements

- An employer can simply hire an individual by telling them they are hired.
- Employers can also have a formal contract that defines rights and responsibilities of the parties
- May be a Union in which terms under which union members work is defined in a collective agreement

Employment Doctrines

- At Will Employment
  - Employer hired a person at will and that action did not confer a right to a job on the employee.
  - Employer can terminate an employee at will for any reason or lack of reason
- The Learned Professional
  - Long formal training in information specific to a field
  - Formal recognition through licensure and certification
  - Have the right to determine the details of their work
  - Quality of work is generally defined through peer standards and evaluation
  - Learned Professional has a code defining their special position of trust and responsibility they have
  - (Engineer has a specific responsibility to public safety)

Conflict of Interest in Employment

- The first Rule and first Fundamental Canon states that "Engineers shall hold paramount the safety, health, and welfare of the public."
- "If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as appropriate."
- "Engineers having knowledge of any alleged violation of this Code shall report thereon to appropriate professional bodies and, when relevant, also to public authorities, ...“
- A Manager or Corporate Entity Employing an Engineer and giving them access to their inner workings may not always be delighted to hear about some of this stuff

When Ethics and the Will of the Employer Collide

- Under the doctrine of At Will Employment the Engineer could loose employment
- A contract may contain something that could be enforced at law as a breach of contract
  - Most of the time the Employer wrote the contract and usually wrote it to their advantage
  - Few contracts will contain language requiring you to conceal things or take illegal actions
    - A contract containing illegalities is not enforceable at law
    - Could set the employer up as systematically conspiring to do something bad

The Public Policy Exception

- Starting in the 60s and picking up in the 80's and 90's there was a recognition that companies could and did use the Doctrine of At Will Employment to protect unlawful conduct and circumvent public policy
- Whistle Blowers began to get some protections
- Terminating an Employee for acting in the interest of Public Policy is generally termed "Wrongful Discharge"

Common Scope of the Public Policy Exception

- the employer ordered the employee to violate a state or federal law, for which the employee could be personally convicted. Such a violation could be either:
  - something the law forbids (e.g., employer orders employee to commit perjury), or
  - something the law requires (e.g., the employee serves on a jury).
- the employee exercised his/her legal right (e.g., filed a workers' compensation claim as the result of an injury in the scope of employment).

Common Scope Continued

- the employee reported a crime, when the employee has a reasonable belief that a crime has been committed.
- the employee cooperated with a criminal investigation.
- the employee has been absent while serving in the military (e.g., National Guard or Reserve).
- the employer ordered the employee to violate a state or federal regulation or statute that is designed to protect the health or safety of other people.

Enforcement of Wrongful Discharge

- Does not require that they actually fire you
  - Demotion and driving you out through making work unlivable can also be Wrongful Discharge
- Requires you to file suite
  - Varies by state as to whether it is treated as a
    - Tort – meaning someone did you a civil wrong
    - Breach of Contract
- Whether Wrongful Discharge took place is usually a question of law not of fact
  - A jury may decide a question of fact – were you discharged in response to an action you took or did not take
  - A Judge decides a question of law – does that termination violate public policy and therefore constitute a wrongful discharge

Scope of Public Policy

- Most courts and states hold that public policy is contained in the Constitution, the laws put out by legislative bodies under that constitution, or regulations defining the implementation of the law
- Only a few cases where the Code of Ethics is recognized as defining a public policy objective
  - Omission can leave a big hole between ethical conduct in protecting the public and professional conduct that will be protected
  - Need to encourage legislatures to confer more legal recognition on the code of ethics

Emerging Case Law

- Most cases have been since 1995
- Public Safety objectives have been getting recognized as being implicit in regulations pertaining to equipment and structures
  - Some of the base cases have involved aircraft
  - Illinois courts have recognized public policy subjects as part of the common law of the state
    - Meaning it does not always have to be spelled out in a statute

Moral Courage

- Doing the right thing is not always going to be legally protected
  - Even where protection exist vindication may be a long and painful road
- Values have to stand up in tough times or they are no more than talk

Contract Provisions

- The Non-Compete Clause
- Non Disclosure Agreement
- Patents and Inventions

What is a Non-Compete Clause

- It says that you will not engage in activities in direct competition with your employer even after you finish employment

The Non-Competition Clause

- Purpose of Non-Competition
  - Prevent people from using insider information to disadvantage their former employer
  - Prevent practices of raiding corporations not for talent but for effective corporate espionage
  - Prevent people from using internal client lists to steal customer base away from a company

Limitations of Non-Competition

- Courts have recognized that out of control non-compete clauses could enslave someone to a corporation (They could not use the skills of their study anyplace else)
  - A non-compete clause should have a time duration
    - 2 to 3 years commonly accepted
    - 5 is pushing it
    - 10 better have a darn good explanation of why the information stays fresh so long
  - Should be limited in field of application
    - A non-compete clause for all practice of engineering or even all Mining Engineering would not likely be accepted
  - Should have reasonable geographic coverage
    - A group that does most of its business in Colorado would be hard pressed to justify a non-compete over North America

Personal Caution on Non-Compete Clauses

- Be careful what you sign
  - Courts are reluctant to overturn the results of individual stupidity
- On Non-Compete Clauses Precedent is clear on them being limited in scope
  - If your writing one
    - A broad or vague clause is likely to be meaningless – details and limits are key to enforceability
    - Claim only what is clearly reasonable to your interests
      - If it looks like you are trying to hamstring your employees the courts will be aggressive in throwing things out
- Be reasonable and cautious in dealing with Non-compete clauses
  - Anything left to the hands of the courts is out of your hands

Non-Disclosure Agreement

- Closely related to non-compete
- May be part of a consulting service since you have to have access to your clients inner workings to serve them
- Will usually protect things like client lists
- Nature of work done on a project
- Processes developed or used in a project
- Findings of a study

Limitations

- Usually quite similar to Non-Compete
- Key thing is limited time frame
  - Two or 3 years on a non-disclosure is almost always safe
  - 5 is probably ok
  - More than 5 and approaching 10 you better either have a good explanation or be a government organization or contractor making things for the military
- Non-Disclosure usually not subject to geographic limitation

Relationship of Non-Compete and Non-Disclosure to Code of Ethics

- Code of Ethics

c. Engineers shall not reveal facts, data, or information without the prior consent of the client or employer except as authorized or required by law or this Code.

4. Engineers shall not disclose, without consent, confidential information concerning the business affairs or technical processes of any present or former client or employer, or public body on which they serve.
   a. Engineers shall not, without the consent of all interested parties, promote or arrange for new employment or practice in connection with a specific project for which the engineer has gained particular and specialized knowledge.
   b. Engineers shall not, without the consent of all interested parties, participate in or represent an adversary interest in connection with a specific project or proceeding in which the engineer has gained particular specialized knowledge on behalf of a former client or employer.

Role of Contract Clauses

- In general the terms set forth in a non-compete clause or non-disclosure agreement can be regarded as defining what the client or former employer expects of you
  - Can be considered to define your obligation under the code of ethics

Ownership of Patents

- Code of Ethics

b. Engineers using designs supplied by a client recognize that the designs remain the property of the client and may not be duplicated by the engineer for others without express permission.

c. Engineers, before undertaking work for others in connection with which the engineer may make improvements, plans, designs, inventions, or other records that may justify copyrights or patents, should enter into a positive agreement regarding ownership.

- S… employer
  - Most also give rights to inventions on your own time
  - (Trying to circumvent people holding out choice pieces of knowledge)

References

- CSUN ME Senior Design Lecture notes
- Engineering Your Future, A Comprehensive Approach, Sixth Edition, by Oakes, Leone, Gunn. Publisher: Great Lake Press
- http://www.asme.org/Education/PreCollege/TeacherResources/Code_Ethics_Engineers.cfm

Lecture 5a
Engineering Disciplines

CENTRAL QUESTIONS FOR ENGINEERING EDUCATION

- What is the full set of knowledge, skills and attitudes that a student should possess as they graduate from university? At what level of proficiency?
  - • In addition to the traditional engineering disciplinary knowledge

- Can we do better at assuring that students learn these skills?
  - • Within the available student and faculty time, funding and other resources

THE NEED

Desired Attributes of an <u>Engineering Graduate</u>

- Understanding of fundamentals
- Understanding of design and manufacturing process
- Possess a multi-disciplinary system perspective
- Good communication skills
- High ethical standards, etc.

<u>Underlying Need</u>

Educate students who:

- Understand how to conceive-design-implement-operate
- Complex value-added engineering systems
- In a modern team-based engineering environment

THE CHALLENGE - TRANSFORM THE CULTURE

CURRENT

- Engineering Science
- R&D Context
- Reductionist
- Individual

DESIRED

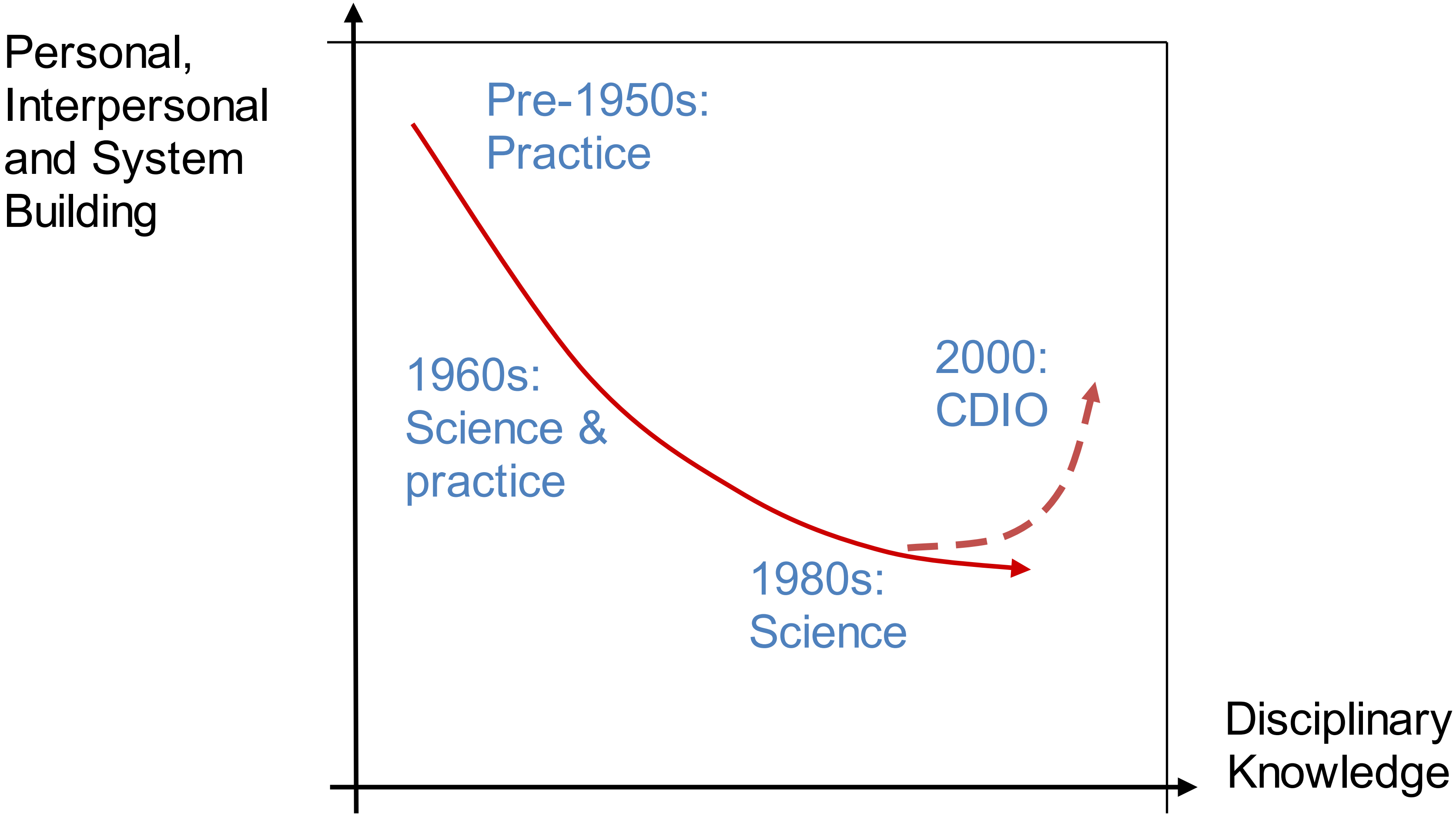
- Engineering
- Product Context
- Integrative
- Team

... but still based on a rigorous treatment of engineering fundamentals

EVOLUTION OF ENGINEERING EDUCATION

- Prior to the 1950s, education was based on practice, taught by distinguished former practitioners
- 1950s saw the introduction of engineering science, and hiring of a cadre of young engineering scientists
- 1960s was the golden era of a balance between the old practitioners and the young engineering scientists
- In the 1980s, the engineering scientists aged – they replaced the practitioners with younger scientists, and the trend towards a scientific based education intensified
- In the 1990s, industry recognized a growing gap between the skills of graduating students and those needed for engineering practice

DEVELOPMENT OF ENGINEERING EDUCATION



Engineers need *both* dimensions, and we need to develop education that delivers both

SUGGESTED GOALS

- To educate students to master a *deeper working knowledge* of the technical fundamentals
- To educate engineers to *lead in the creation and operation* of new products and systems
- To educate future researchers to understand the importance and *strategic value of their work*

EXAMPLE VISION

We envision an education that stresses the fundamentals, set in the context of Conceiving - Designing - Implementing - Operating systems and products:

- A curriculum organised around mutually supporting disciplines, but with CDIO activities highly interwoven
- Rich with student design-build projects
- Featuring active and experiential learning
- Set in both the classroom and a modern learning laboratory/workspace
- Constantly improved through robust assessment/evaluation process.

PEDAGOGIC LOGIC

- Most engineers are "concrete operational learners"
  Manipulate objects to understand abstractions
- Students arrive at university lacking personal experience
  Lack foundation for "formal operational thought"
- Must provide *authentic activities* to allow mapping of new knowledge – alternative is rote or "pattern matching"
- Using CDIO as authentic activity achieves two goals --
  Provides activities to learn fundamentals
  Provides education in the creation and operation of systems

APPROACH

Our approach is to ***design*** (in the engineering sense) an improved educational model and implementable resources.

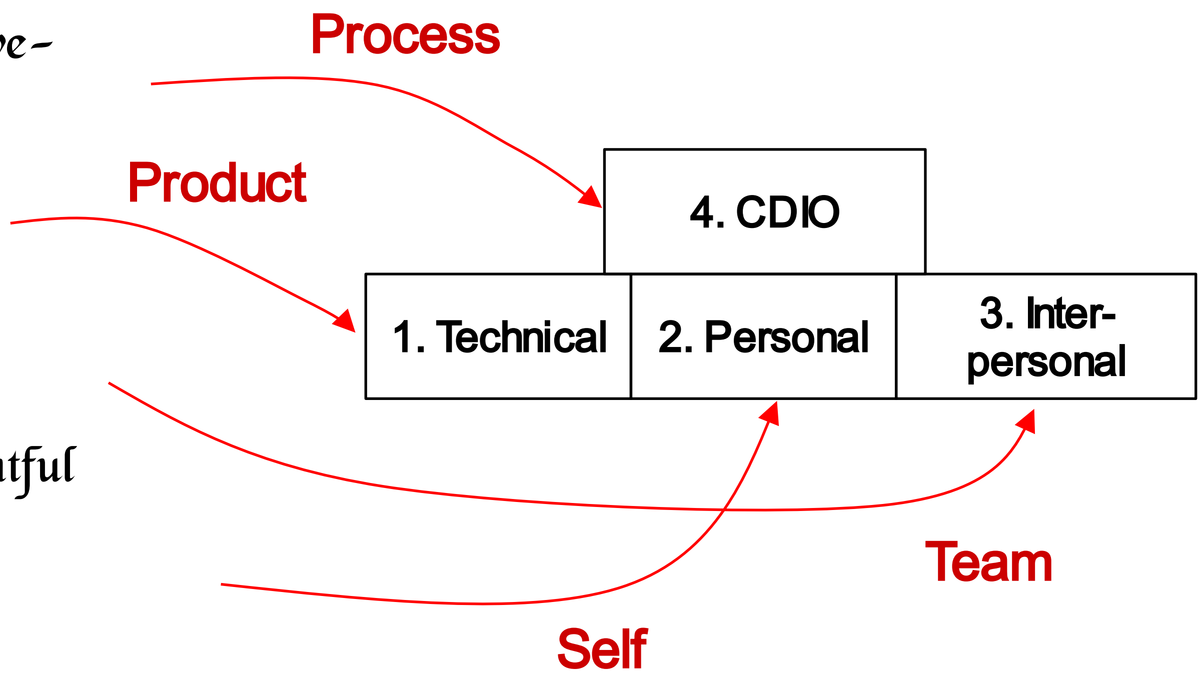
- Analyze needs, and set a clear, complete and consistent set of goals
- Design and prototype in parallel programs with partner universities
- Compare results,evaluate, iterate and develop improved models and materials
- Create as open source of resources, <u>not</u> a prescription

** With the financial support of the Knut and Alice Wallenberg Foundation

NEED TO GOALS

Educate students who:

- Understand how to conceive-design-implement-operate
- Complex value-added engineering systems
- In a modern team-based engineering environment
- And are mature and thoughtful individuals



The CDIO Syllabus - a comprehensive statement of detailed Goals for an Engineering Education

WHAT IS THE SET OF SKILLS?

- Technical Knowledge & Reasoning:
  Knowledge of underlying sciences
  Core engineering fundamental knowledge
  Advanced engineering fundamental knowledge

- Personal and Professional Skills & Attributes
  Engineering reasoning and problem solving
  Experimentation and knowledge discovery
  System thinking
  Personal skills and attributes
  Professional skills and attributes

- Interpersonal Skills: Teamwork & Communication
  Multi-disciplinary teamwork
  Communications
  Communication in a foreign language

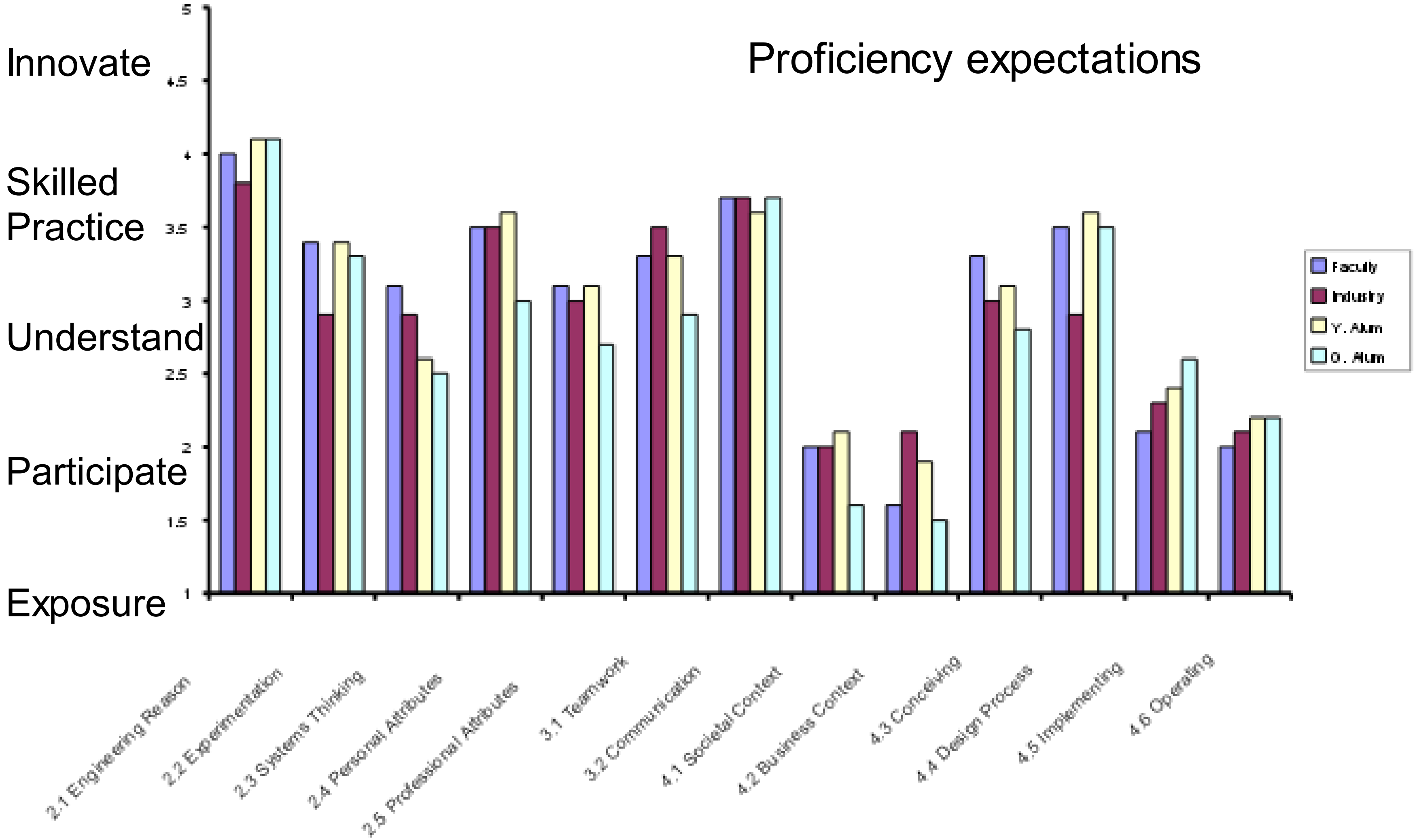
- Conceiving, Designing, Implementing & Operating Systems in the Enterprise & Societal Context
  External and societal context
  Enterprise and business context
  Conceiving and engineering systems
  Designing
  Implementing
  Operating

SYLLABUS LEVEL OF PROFICIENCY

- 6 groups surveyed: 1st and 4th year students, alumni 25 years old, alumni 35 years old, faculty, leaders of industry
- Question: For each attribute, please indicate which of the five levels of proficiency you desire in a graduating engineering student:

- 1 To have experienced or been <u>exposed</u> to
- 2 To be able to <u>participate</u> in and contribute to
- 3 To be able to <u>understand</u> and explain
- 4 To be <u>skilled in the practice</u> or implementation of
- 5 To be able to lead or <u>innovate</u> in

Proficiency expectations



REMARKABLE AGREEMENT!

CAN WE DO BETTER?

We can if we retask:

- Curriculum
- Laboratories and workspaces
- Teaching resources
- Assessment
- Faculty competence

And evolve to a model in which these resources are better employed to promote student learning

RETASKING CURRICULAR ASSETS

How can we create:

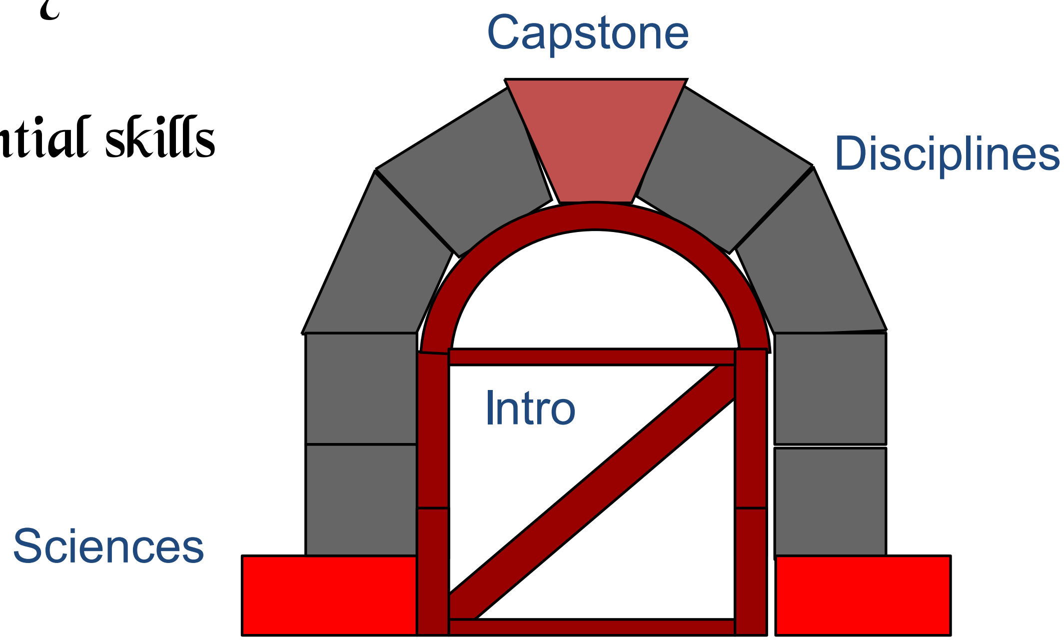
- Mutually-supportive disciplinary subjects integrating personal, professional and product/system building skills?
- An introductory course that provides a framework for engineering education?

INTEGRATED SKILLS

SyllabusTopic	I	T	U
2.1 Engineering reasoning and problem solving		x	x
2.2 Experimenting and knowledge discovery.	x	x	x
2.3 System thinking .		x	x
2.4 Personal skills and attributes .			x
2.5 Professional skills and attributes .			x
3.1 Teamwork .			x
3.2 Communications .		x	
3.3 Communication in foreign languages .			x

INTRO SUBJECT - THE FRAMEWORK

- To motivate students to study engineering
- To provide a set of personal experiences which will allow early fundamentals to be more deeply understood
- To provide early exposure to system building
- To teach some early and essential skills (e.g., teamwork)



RETASKING LABS AND WORKSPACES

How can we:

- Insure that students participate in repeated design-build experiences?
- Develop workshops that support hands-on learning of product/system building, disciplinary knowledge, knowledge discovery, social learning?

DESIGN-BUILD EXPERIENCES

Design build experiences:

- Provide authentic activities onto which more abstract learning can be mapped
- Provide the natural context in which to teach many CDIO syllabus skills (teamwork, communications, designing, implementing)

- Reinforce by application previously learned abstract knowledge, to deepen comprehension

Reinforcing Disciplinary Knowledge

Knowledge Discovery

Learning Lab

System Building

Community Building

RETASKING TEACHING RESOURCES

How can we:

- Provide authentic experience supporting deep and conceptual learning of technical knowledge, as well as personal, interpersonal and product/system building skills?
- Employ teaching and learning methods based on active and experiential models?

INTEGRATED LEARNING EXPERIENCES

- In disciplinary subjects, it is possible to construct learning exercises which integrate both technical learning and learning of Syllabus skills (problem solving, system thinking, experimentation, etc.)

- It is important for students to see their role models, the engineering faculty, involved with issues such as ethics, communication, enterprise and societal issues.

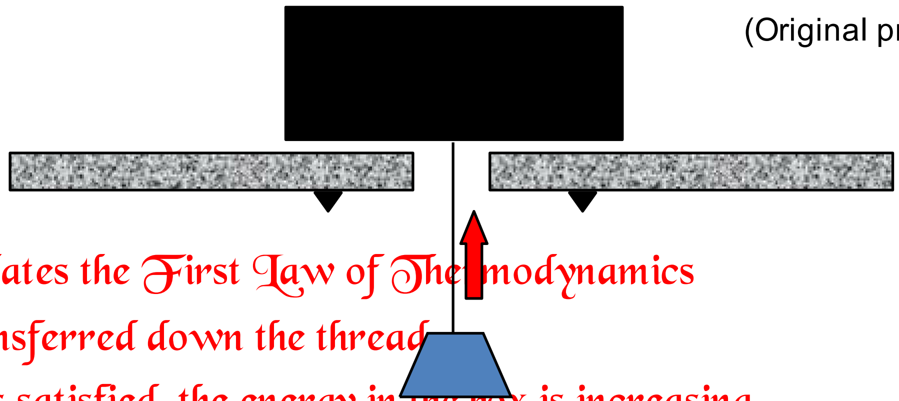
- Active learning techniques stress students' active involvement in their own learning; rather than simply passively listening
- Project-based and design-build courses epitomize active learning
- Lecture-based courses can include one or several active learning strategies, such as muddiest-point-in-the-lecture cards, concept questions, and turn-to-your-partner discussions.

CONCEPT QUESTIONS

A black box is sitting over a hole in a table. It is isolated in every way from its surroundings with the exception of a very thin thread which is connected to a weight.

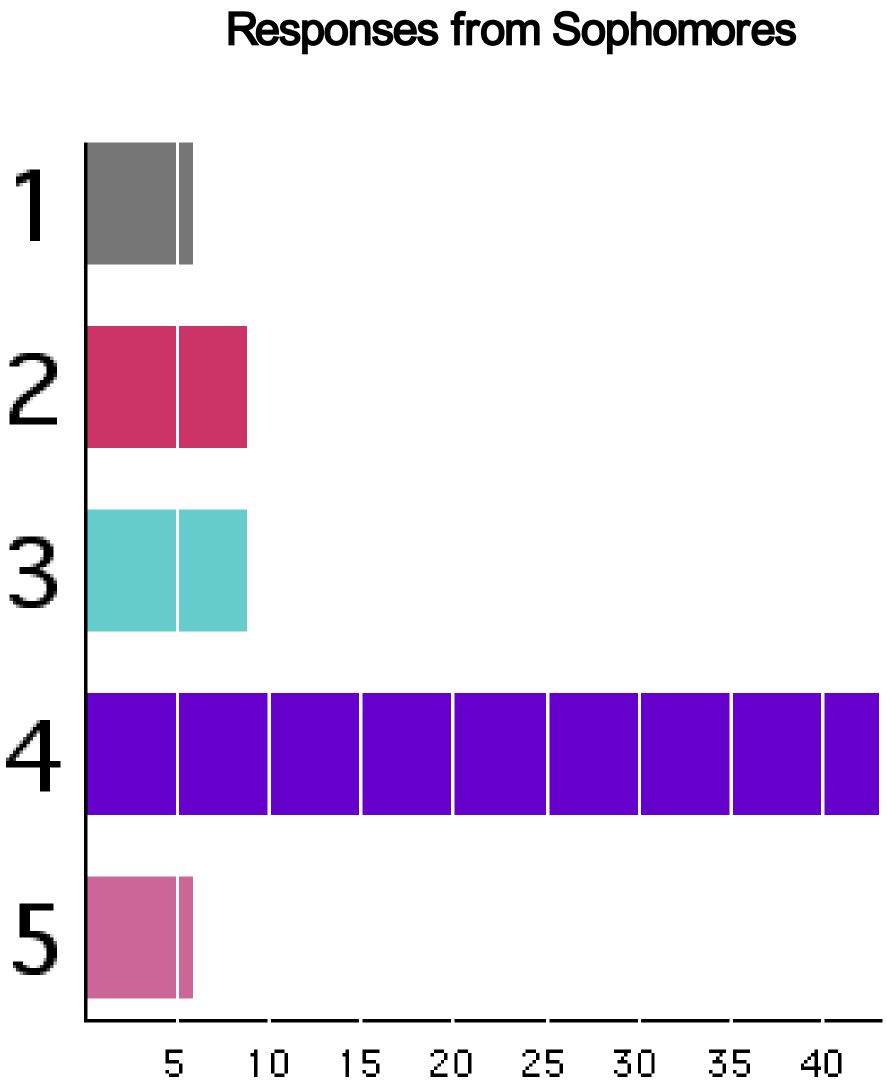
You observe the weight slowly moving upwards towards the box.

(Original problem due to Levenspiel, 1996)



1) This situation violates the First Law of Thermodynamics
2) Heat must be transferred down the thread
3) The First Law is satisfied, the energy in the box is increasing
4) The First Law is satisfied, the energy in the box is decreasing
5) The First Law is satisfied, the energy in the box is constant

REAL-TIME PRS RESPONSE



RETASKING FACULTYCOMPETENCE

How can we enhance faculty competence:

- In personal, interpersonal and product/system building skills?
- In active and experiential teaching and learning, and in assessment?

RETASKING ASSESSMENT ASSETS

How can we create:

- Assessment of student learning that measures student knowledge and skills in personal, interpersonal and system building, as well as traditional disciplinary knowledge?
- Evaluate programs against the rigorous goals of the CDIO initiative?

ASSESSMENT OF STUDENT LEARNING

- Assessment methods matched to course learning objectives
- Creation of tools to assess personal, interpersonal, and product and system-building skills
  - technical presentation
  - written and graphic communication
  - team collaboration
  - product assessment
- Self-assessment, reflection on learning achievement through journals, portfolios
- Timely feedback to students so they can improve their learning

THE CDIO STANDARDS

1. CDIO as Context*
Adoption of the principle that product and system lifecycle development and deployment are the context for engineering education

2. CDIO Syllabus Outcomes*
Specific, detailed learning outcomes for personal, interpersonal, and product and system building skills, consistent with program goals and validated by program stakeholders

3. Integrated Curriculum*
A curriculum designed with mutually supporting disciplinary subjects, with an explicit plan to integrate personal, interpersonal, and product and system building skills

4. Introduction to Engineering
An introductory course that provides the framework for engineering practice in product and system building, and introduces essential personal and interpersonal skills

5. Design-Build Experiences*
A curriculum that includes two or more design-build experiences, including one at a basic level and one at an advanced level

6. CDIO Workspaces
Workspaces and laboratories that support and encourage hands-on learning of product and system building, disciplinary knowledge, and social learning

7. Integrated Learning Experiences*
Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal, interpersonal, and product and system building skills

8. Active Learning
Teaching and learning based on active experiential learning methods

9. Enhancement of Faculty CDIO Skills*
Actions that enhance faculty competence in personal, interpersonal, and product and system building skills

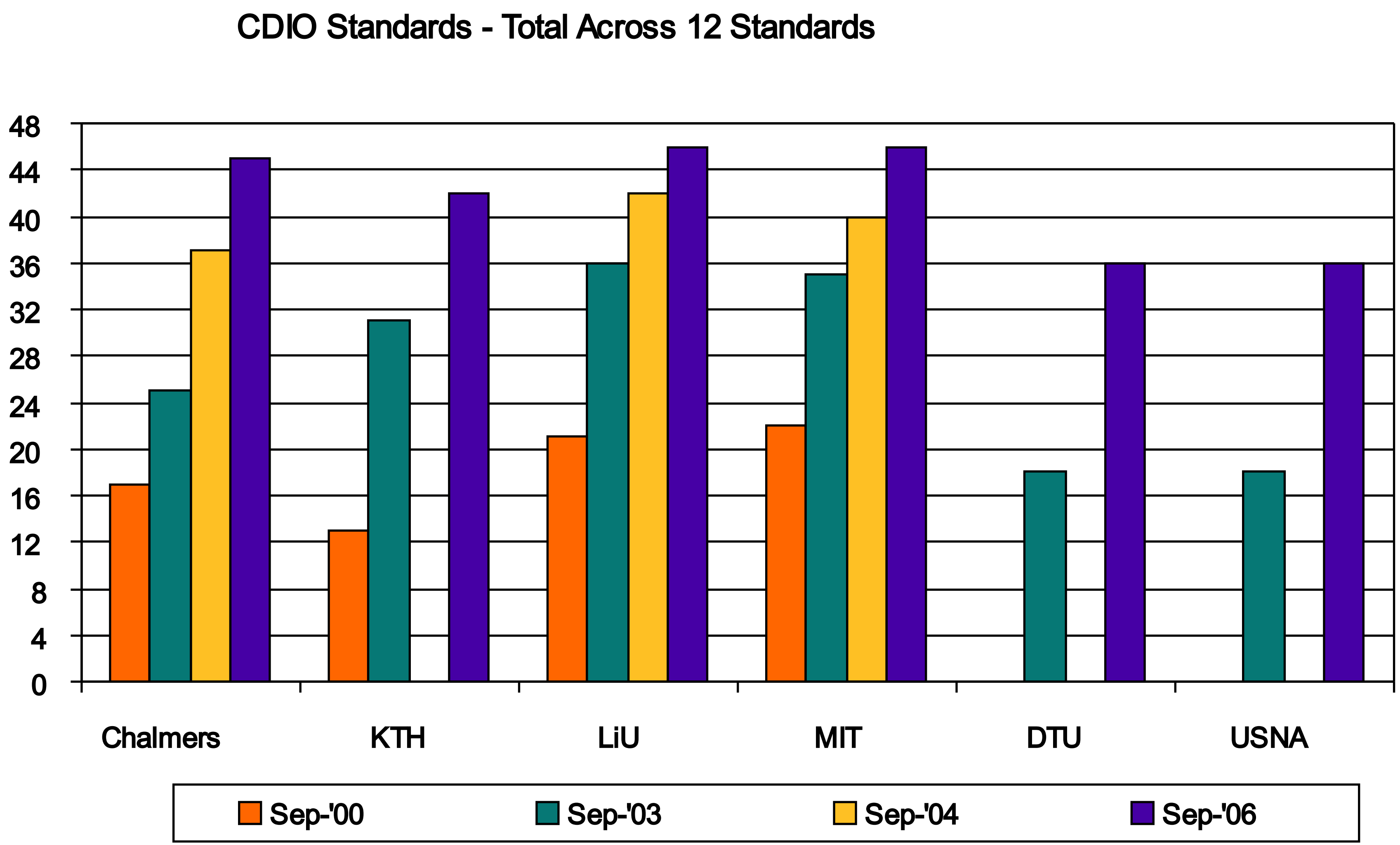
10. Enhancement of Faculty Teaching Skills
Actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods, and in assessing student learning

11. CDIO Skills Assessment*
Assessment of student learning in personal, interpersonal, and product and system building skills, as well as in disciplinary knowledge

12. CDIO Program Evaluation
A system that evaluates programs against these 12 standards, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement

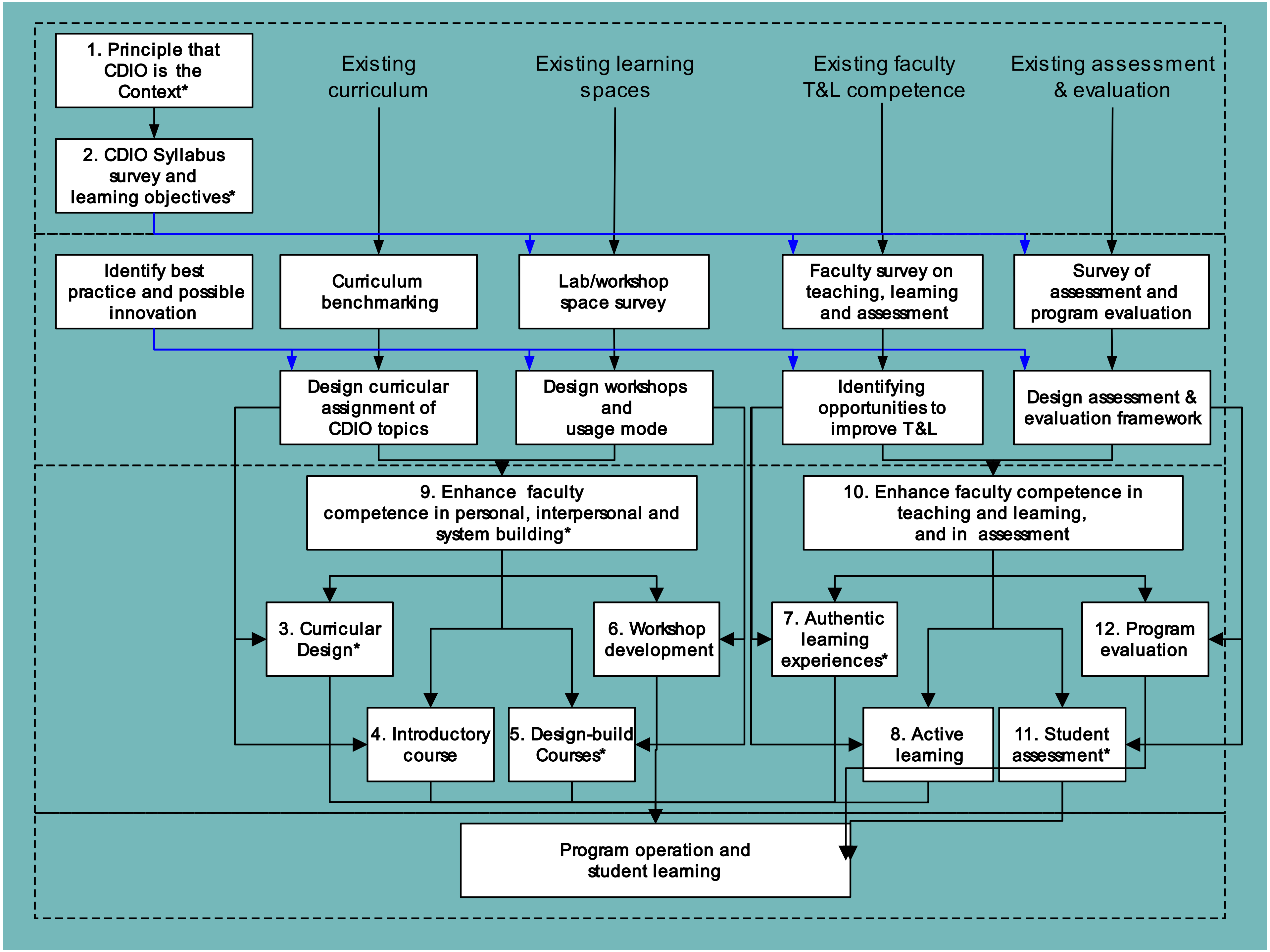
*required

EVALUATE PROGRAMS AGAINST CDIO GOALS



CHANGE PROCESS

- Understanding of need, and commitment
- Leadership from the top
- Early adopters
- Quick successes
- Adequate resources
- Faculty learning
- Faculty recognition


1. Principle that CDIO is the Context*
2. CDIO Syllabus survey and learning objectives*
Existing curriculum
Existing learning spaces
Existing faculty T&L competence
Existing assessment & evaluation
Identify best practice and possible innovation
Curriculum benchmarking
Lab/workshop space survey
Faculty survey on teaching, learning and assessment
Survey of assessment and program evaluation
Design curricular assignment of CDIO topics
Design workshops and usage mode
Identifying opportunities to improve T&L
Design assessment & evaluation framework
9. Enhance faculty competence in personal, interpersonal and system building*
10. Enhance faculty competence in teaching and learning, and in assessment
3. Curricular Design*
6. Workshop development
7. Authentic learning experiences*
12. Program evaluation
4. Introductory course
5. Design-build Courses*
8. Active learning
11. Student assessment*
Program operation and student learning

CDIO INITIATIVE OUTCOMES

- Create a model, a change process and open source on-line library of education materials that facilitate easy adaptation:
  - Start up support and guidance
  - Examples and synthetic evaluations in iKit
  - Workshops to interest and educate the faculty
  - An evolving community for interaction, development and ongoing contributions
- Have programmatic impact at many universities
- Significantly increase the number of students worldwide who can conceive-design-implement-operate new products and systems

LONG-TERM VISION

The CDIO Initiative has:

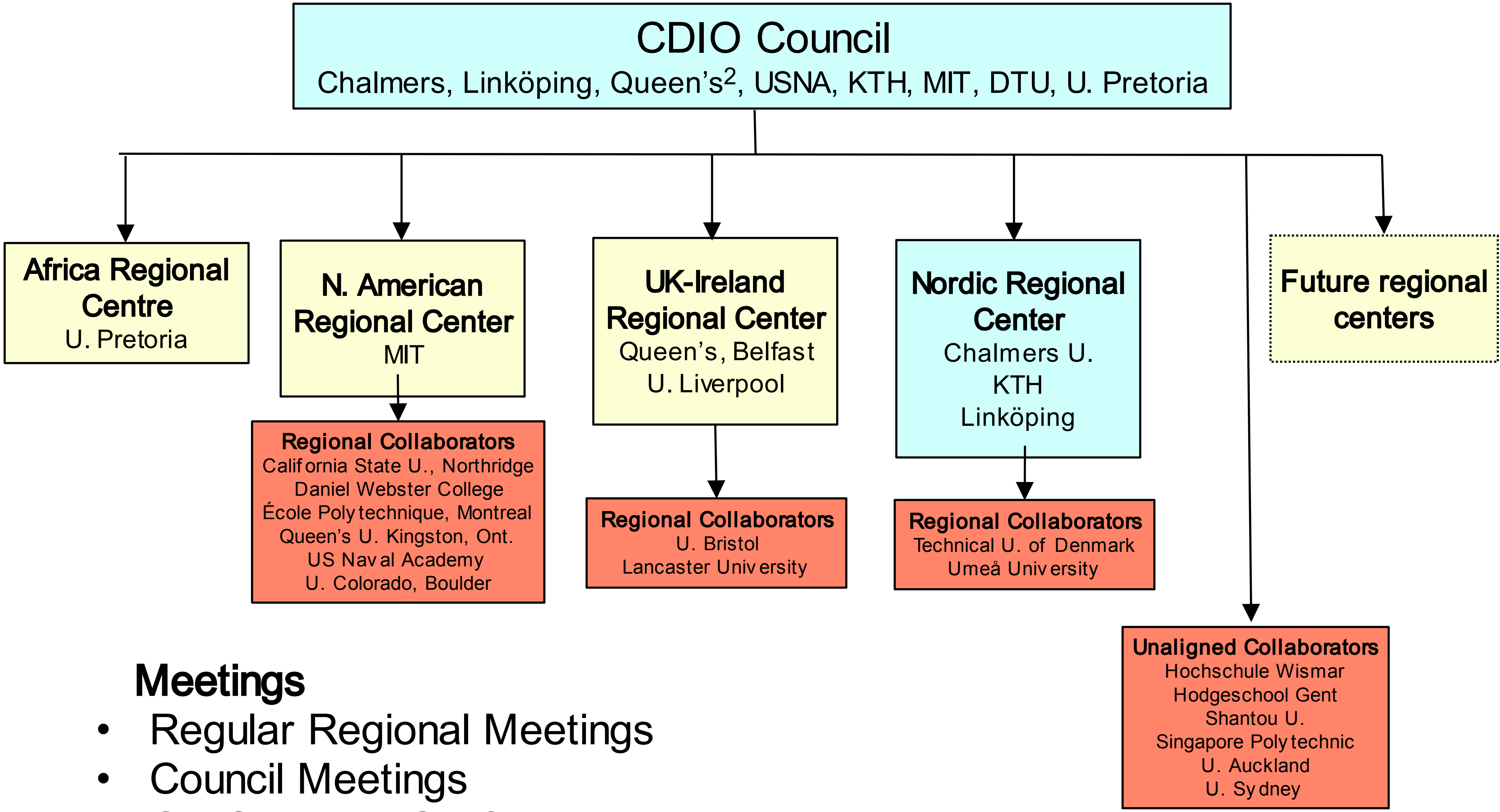
- created a model, a change process and library of education materials that facilitate easy adoption of the CDIO programs
- is having programmatic impact at a growing number of universities around the world
- is increasing the number of students worldwide who can conceive-design-implement-operate new products and systems

INVITATION

- The model is still a postulate
- Many universities are developing important elements of this fabric – learning materials, teaching and learning approaches, assessment tools, views of space
- CDIO is a Web-based open architecture to which all can contribute and draw from
- We invite you to join as a collaborator

- Web
  - www.cdio.org
  - Collaborators' sites
- Published papers
- Conference presentations
- WOM (word-of-mouth)
- Media coverage
  - Professional publications
    - Academic
    - Industry
  - General media
- Workshops
- Site visits
  - School
  - Industry
- Book

CDIO INITIATIVE STRUCTURE



Meetings

- Regular Regional Meetings
- Council Meetings
- CDIO Annual Conference

LEARN MORE ABOUT CDIO

Assignment No. 5
Submit next meeting

- Select one engineering discipline of your interest and make a report. Indicate on your report on how you can contribute to the development of your home place and the country as a whole. Write your report in 3 to 4 pages A4 size paper.

Lecture 5b
Seminar Presentation

C.M. Pascual
Professor, CACE

Effective Presentations

"Great speakers aren't born, they are trained."

Presenting is a Skill...
Developed through training and experience

Topic

- Introduction
- Planning your presentation
- The presentation sequence
- Creating effective visual aids
- Effective presentation techniques

Introduction

Why Give A Presentation?

Three Main Purposes

1. Inform
2. Persuade
3. Educate

Definitions

Presentation

- "Something set forth to an audience for the attention of the mind "

Effective

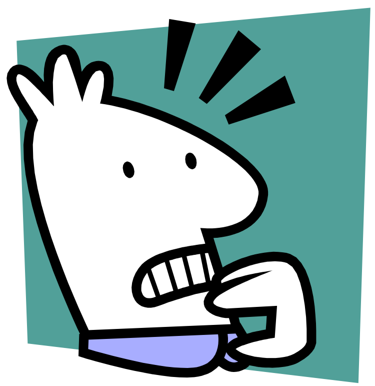
- "...producing a desired result"

#1 Fear

- Feared more than death!
- THE FACTS: Shaky hands, blushing cheeks, memory loss, nausea, and knocking knees
- NORMAL!

Causes of the Anxiety

- Fear of the unknown OR loss of control
- Fight or flight mode
- No backup plan
- No enthusiasm for subject
- Focus of attention



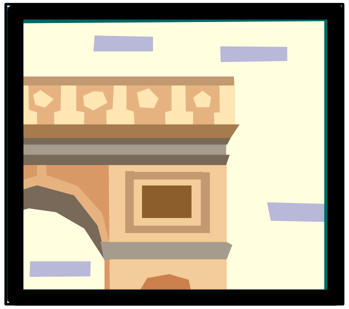
Effective Presentations

- Control anxiety - Don't fight it
- Audience centered
- Accomplishes objective
- Fun for audience
- Fun for you
- Conducted within time frame

Planning Your Presentation

Planning Your Presentation

1. Determine purpose
   - What do you want to accomplish?
2. Know your audience !!!
   - Success depends on your ability to reach your audience
   - Size
   - Demographics
   - Knowledge level
   - Motivation
   - Why are they attending?
   - What do *THEY* expect?



More Planning

3. Plan Space
   - Number of attendees and seats
   - Seating arrangement
   - Lighting, and lighting controls
   - Audio/Visual equipment
   - Distracters
4. What Day and Time?
   - Morning
   - Afternoon
   - Evening
   - Work day versus weekend
   - Any day!

Still More Planning

5. Organization
   - Determine main points (1-5)
   - Evidence
   - Transitions
   - Prepare outline
   - Prepare a Storyboard
6. Rehearse...Rehearse...Rehearse!!
   - In the actual room if possible
   - Work to a script and time your presentation
   - Practice Q & A
   - Check equipment - load your slides in advance
   - Make contingency plans

Organizing Your Presentation

<u>Organizational patterns</u>

- Topical
- Chronological
- Problem/Solution
- Cause/Effect

Presentation Outline

- Keyword reminders
- Conversational flow
- Flexibility
- More responsive to audience

Storyboarding

The Presentation Sequence

#1: Build Rapport

- … relation marked by harmony or affinity
  - Audience members need to trust you and feel that you care about them
- Start before you begin
  - Mingle; learn names
  - Opportunity to reinforce or correct audience assessment
  - Good first impression
- People listen to people they like

#2: Opening Your Presentation

- Introduce yourself
  - Why should they listen
- Get attention, build more rapport, introduce topic
  - Humor
  - Short story
  - Startling statistic
  - Make audience think
  - Invite participation
- Get audience response

#2...Completing the Opening

- Clearly defining topic
- If informative...
  - Clear parameters for content within time
- If persuasive...
  - What's the problem
  - Who cares
  - What's the solution
- Overview

#3: Presenting Main Points

- Make point-transition,...make point-transition, ...make point-transition, etc...
- Supporting evidence
- Examples
- Feedback & questions from audience
- Attention to, and focus on, audience... are they listening?

#4: Concluding Your Presentation

<u>**Goal**</u>

- Inform audience that you're about to close
- Summarize main points
  - "Tell 'em What You Told 'em."
- Something to remember, or call-to-action
- Answer questions

Creating Effective Visual Aids

Designing Good Slides

- Content
  - If it doesn't add value, don't say/use it
- Unveiling
  - Is drama useful or necessary?
- Color
  - Know your room and lighting
    - Dark room - use light font on dark background
    - Bright room - use dark font on light background
- Subliminal messages
  - Consider your audience and use carefully

Content

- Purpose
  - Complement speaker
  - Talk ≠ technical report
- Density
  - 7-10 lines/page
  - 4-8 words/line
  - Test: Project a sample in the room, or in a room of approximately the same size as will be used in the real presentation

Visual Aids

- To make, explain or identify a point
- To emphasize, clarify or reinforce a point
- To remind, summarize or review a point

- We remember –
  - 10% of what we read
  - 20% of what we hear
  - 30% of what we see
  - 50% of what we see and hear

Visual Aids

- Enhance understanding
- Add variety
- Support claims
- Lasting impact

Used poorly, however, they can be a distraction and lead to an <u>ineffective</u> presentation

Visual Aids

- PowerPoint slides
- Overhead transparencies
- Graphs/charts
- Pictures
- Web links (http://www.unh.edu/uacc/unhpathways.html)
- Films/video
- Flip charts
- Sketches
- Chalk or white board

Visual Aids Should...

- Outline, explain, support main points
- Serve audience's needs, not speaker's
- Be simple and clear
- Supplement and support...
  <u>NOT DOMINATE!...</u>
  the presentation

Be Visible

- Use Sans Serif fonts (fonts without feet)
  - e.g. Arial, Tahoma, Trebuchet, Verdana, etc.
- Titles should be 32-44 pt. font size, **BOLD**
- Text should be as large as possible
  - First level 24-32 pt font size
  - Second level 20-28 pt font size
  - Etc.
- Use color wisely
  - Contrasting colors

Red/Blue Conflict

Red letters on blue background creates “flicker effect”

Blue letters on red background just as bad

Low Contrast

White on yellow

Yellow on white

Black on blue

Blue on black

"Fly-In" vs "Wipe"

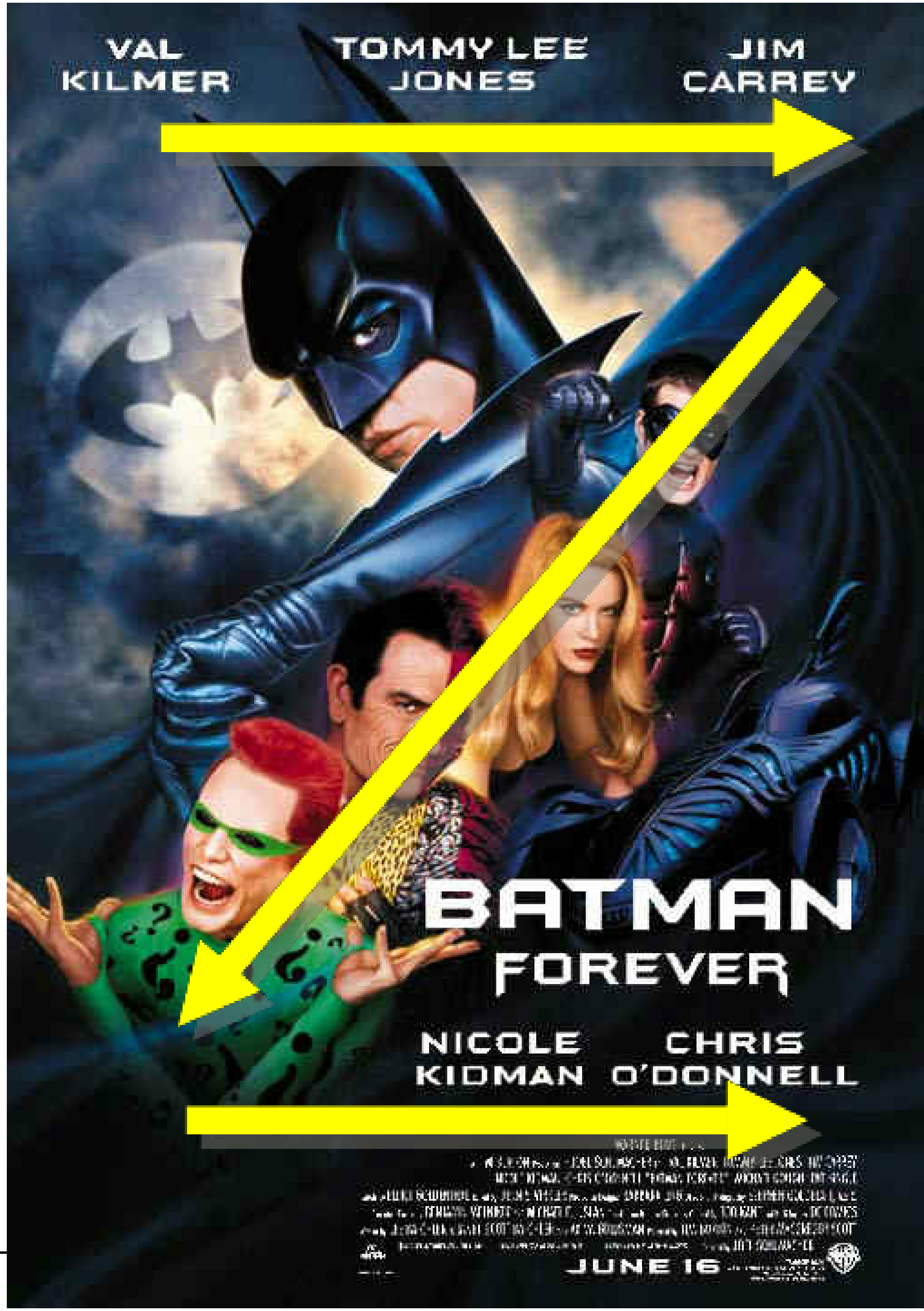
- Could you read this?
- How about this one?
- Maybe the third time is the charm!

- Less distracting
- Reduces eye movement
- Increases readability

Be **CONSISTENT** throughout presentation!

Eye Movement
The “Z” Rule

- Upper left
- Upper right
- Lower left
- Lower right



Effective
Presentation Techniques

What Makes an Effective Speaker?

- Control of information
- The voice used
- The right words
- Use of body language
- Prompts, scripts and notes
- The right location
- Useful and meaningful visual aids

Vocal Techniques

- Loudness
  – Will you be using a microphone?
- Pitch
  – Vary to make points
- Rate
  – Watch your audience
- Pause for effect
  – Allow time for message to "sink in"
- Deviate from the norm for emphasis

The Voice

C: Clear - the use of simple, easily understood words and phrases

L: Loud (enough) - it is important that everyone can hear you

A: Assertive - a bright and confident air born of knowledge of the subject and good preparation

P: Pause - it is essential to allow the listeners time to digest what you have said

Use the Rights Words

What you say, and ***how you say it,***
is the key to a successful presentation:

P - state your position or point

R - explain your ideas

E - use examples

P - restate your position or point

Use of Body Language

- Make eye contact
- Use your hands, but don't go crazy
- If possible move around, but slowly!
- DON'T speak with your back to the audience

Body Language

- Make eye contact,…but move focus around the audience
- Use your hands,…but don't go crazy
- If possible move around,…but slowly!
- Maintain good posture
- Make sure everyone can see you
- DON'T speak with your back to the audience

Scripts and Notes

- Learn and use a script for formal presentations to large groups
- Small note cards, or PPT notes page, can be used, but FIRST write a script
- Underline key words that will best remind you what you want to say
- Use one card for each slide or topic
- If possible, have someone else advance slides for you

Speaker Reads Slides

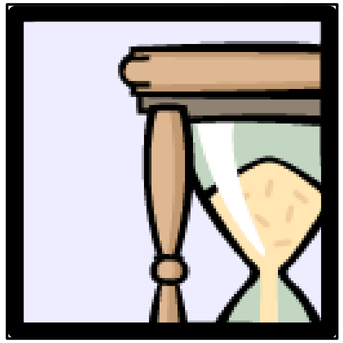
- A speaker may put his entire presentation on his slides. He turns his back to the audience and reads the slides aloud. Perhaps he feels this approach guarantees all the information will get to the audience.
- This may be the most annoying way to give a presentation. Audience members feel insulted; they already know how to read! They wo the lecturer doesn't simply hand out a cop ides.
- The visual presentation dominates the . The presenter is not adding any value to what is on the slides.

Psst! This slide is way too busy!

Common Problems

- Verbal fillers
  - "Um", "uh", "like", "you guys"
  - Any unrelated word or phrase
- Swaying, rocking, and pacing
- Hands in pockets
- Lip smacking
- Fidgeting
- Failure to be audience-centered

Pauses



- Useful
  - Awaiting thought
  - Switching gaze
  - Reading slide
  - Reinforcing point
- Powerful
- Difficult

Control of Information

- Know your subject well
- Know what you are talking about
- Practice
- More practice
- More rehearsals
  - in front of the mirror
  - in front of colleagues or friends
  - in front of family members
- Believe in yourself
- Know your opening by heart

Closing Summary

- Audience is always attentive at the begining
- Somewhat less attentive in the middle
- Generally more attentive at the end
- Tell them what you are going to say
- Then say it
- At the end, say it again
- Allow time for questions

Questions and Answers

Opportunities

- Welcoming gestures
- Focusing gaze
- Body language
- Getting point
- Reinforcing message
- Including audience

Pitfalls

- Hostile gestures
- Wandering gaze
- Body language
- Missing point
- Seeking approval
- Excluding audience

5 Presentation Tips

1. **Smile**
2. **Breathe**
3. **Water**
4. **Notes**
5. **Finish on, or under time**

Summary

Guide audience gently

Design slides carefully

Use pauses effectively

Answer questions inclusively

Reference

- **Peter Masucci**, <u>*Adjunct Professor of Marketing,*</u> University of New Hampshire, *Whittemore School of Business and Economics. Jan 2007*

Questions ?

Chapter 15

Ethics and Engineering

Lecture Objectives and Activitivies

- Teach fundamental principles and canons of engineering ethics
  - Clarification of nature of ethics
  - Process to resolve ethical dilemmas
  - NCEES Model Rules of Professional Conduct
  - ASME Code of Ethics
- Provide case studies to examine issues and resolve problems from a second person perspective

The Nature of Ethics

- Ethics is generally concerned with rules or guidelines for morals and/or socially approved conduct
- Ethical standards generally apply to conduct that can or does have a substantial effect on people's lives

Law vs. Ethics

- LAW
  - Creates rules to guide conduct
  - Balances competing values
  - Punishes conduct that is "illegal" through formal structures
- ETHICS
  - Offers guidance on conduct
  - Addresses situations in which competing values clash
  - Incentives and disincentives may be created by "group" (formal or informal)

Is “legal” the same as “ethical?”

- YES:
  - Law defines duties, rights, “allowable conduct.”
  - Compliance approach to business ethics: fulfill legally recognized duties, and don’t go further.
- NO:
  - Law does not address all ethical dilemmas
  - Legal duties may not meet standard of ethical conduct
  - “Beyond Compliance” approach: fulfill legally recognized duties, but don’t stop there.

In case of conflicts, it’s generally held that legal standards must give way to ethical standards

From CSUN ME Senior Ethics Lecture

Consider This: "You and Al"

- You are the manager for Big-Mart, a large discount retailer. You recently fired Al, a sales clerk, after Al punched a customer during a dispute in the store (Al admitted this after the customer complained).
- Sue, manager of your competitor, Mega-Mart, calls you to tell you that Al has applied for a job at Mega-Mart, and to ask you whether Al is "good with customers."
- *WHAT DO YOU DO*?

“An ethical dilemma?”

- Choice to be made
- Implicates competing values, rights, & goals
- Potential harm to decision maker?
- Potential harm to others?
- “Ripple effect:” long-term, far reaching implications of decision to be made.

How to Resolve Ethical Dilemmas

- Identify relevant facts
- Identify relevant issue(s)
- Identify primary stakeholders
- Identify possible solutions
- Evaluate each possible solution
- Compare and assess consequences
- Decide on solution
- Take action

From CSUN ME Senior Ethics Lecture

How to Evaluate Solutions: Some Theories

- **Stakeholder/utilitarian theory**: greatest good to the greatest number
- **Rights Theory**: Respecting and protecting individual rights to fair and equal treatment, privacy, freedom to advance, etc.
- **Justice Theory**: fair distribution of benefits and burdens: can harm to individual be justifiable?
- **Categorical Imperative**: "what if everyone took such action?"
- "**Front Page Test**:" What if my decision was reported on the front page of the *Los Angeles Times*?

Legal vs. Ethical: You and Al

	"Legal"	Illegal
Ethical?	"Al admitted to punching a customer."	[You contact another store, X-Mart, to warn about Al]
Unethical?	"No comment"	"He is great with customers."

From CSUN ME Senior Ethics Lecture

NCEES Model Rules of Professional Conduct

NCEES is the National Council of Examiners for Engineering and Surveying

http://www.ncees.org/

The Preamble

- Purpose is to “ … safeguard life, health, and property, to promote the public welfare, and to maintain a high standard of integrity and practice.”

Obligation to Society

- Broad context of responsibility
  1. "While performing services, the engineer's foremost responsibility is to the public welfare"
  2. "Engineers shall approve only those designs that safeguard the life, health, welfare, and property of the public while conforming to accepted engineering standards"
- Whistle blowing
  3. "If an engineer's professional judgment is overruled resulting in danger to the life, health, welfare, or property of the public, the engineer shall notify his/her employer or client and any appropriate authority"

Obligation to Society

- Truth in duties
  4. “Engineers shall be objective and truthful in professional reports, statements, or testimonies and shall provide all pertinent supporting information relating to such items”
  5. “Engineers shall not express a professional opinion publicly unless it is based upon knowledge of the facts and a competent evaluation of the subject matter”
- The Duty of Full Disclosure
  6. “Engineers shall not express professional opinion on subject matters for which they are motivated or paid, unless they explicitly identify the parties on whose behalf they are expressing the opinion and reveal the parties’ interest in the matters”

Obligation to Society

- "Clean Hands" Rule
  7. "Engineers shall not enter business ventures or permit their names or their firm's names to be used by any persons or firm which is engaging in dishonest, fraudulent, or illegal business practice"
- Final Obligation to Society
  8. "Engineers who have knowledge of possible violation of any of the rules listed in this and the following two parts shall provide pertinent information and assist the state board in reaching final determination of the possible violation"

Engineer’s Obligation to Employers and Clients

- Professional competence
  1. “Engineers shall not undertake technical assignments for which they are not qualified”
  2. “Engineers shall approve or seal only those plans or designs that deal with subjects in which they are competent and which have been prepared under their direct control and supervision”

Engineer’s Obligation to Employers and Clients

- Professional competence
  1. “Engineers shall not undertake technical assignments for which they are not qualified”
  2. “Engineers shall approve or seal only those plans or designs that deal with subjects in which they are competent and which have been prepared under their direct control and supervision”

Engineer’s Obligation to Employers and Clients

- The Validity of Approvals

“Engineers may coordinate an entire project provided that each design component is signed or sealed by the engineer responsible for that design component”

Engineer's Obligation to Employers and Clients

- Confidentiality Requirement

"Engineers shall not reveal professional information without the employer's or client's prior consent except as authorized or required by law"

Engineer’s Obligation to Employers and Clients

- Conflict of Interest

1. “Engineers shall not solicit or accept direct or indirect considerations, financial or otherwise, from contractors, their agents, or other parties while performing work for employers or clients”

2. “Engineers shall disclose to their employers or clients potential conflicts of interest or any other circumstances that could influence or appear to influence their professional judgment or their service quality”

Engineer’s Obligation to Employers and Clients

- Full Disclosure

“An engineer shall not accept financial or other compensation from more than one party for services rendered on one project unless the details are fully disclosed and agreed by all parties”

Engineer's Obligation to Employers and Clients

- Government Conflicts of Interest

"To avoid conflicts of interest, engineers shall not solicit or accept a professional contract from a governmental body on which a principal or officer of their firm serves as a member. An engineer who is a principal or employee of a private firm and who serves as a member of a governmental body shall not participate in decisions relating to the professional services solicited or provided by the firm to the governmental body"

Engineer’s Obligations to Other Engineers

- Obligation to Potential Employers

“Engineers shall not misrepresent or permit misrepresentation of their or any of their associate’s academic or professional qualifications. They shall not misrepresent their level of responsibility or the complexity of prior assignments. Pertinent facts relating to employers, employees, associates, joint ventures, or past accomplishments shall not be misrepresented when soliciting employment or business”

Engineer’s Obligations to Other Engineers

- Conflicts of Interest

“Engineers shall not directly or indirectly give, solicit, or receive any gift or commission, or other valuable consideration, in order to obtain work, and shall not make contribution to any political body with intent of influencing the award of contract by governmental body”

Engineer’s Obligations to Other Engineers

- Reputations of Other Engineers

1. “Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputations, prospects, practice or employment of other engineers, nor indiscriminately criticize the work of other engineers”
2. Criticize cautiously and objectively with respect to the person’s professional status

Engineering Ethics and Legal Issues

- Contract Law

Mutual agreement between two or more parties to engage in transaction which provides benefits to each of them

1. Mutual consent
2. Offer and acceptance
3. Consideration

Engineering Ethics and Legal Issues

- Other Contract Issues

1. Legally enforceable agreement requires a definite promise by each party to do something specific
2. Some benefit received that each did not have before
3. Does not have to be in writing to be valid

Engineering Ethics and Legal Issues

- Breach of Contract

An actual violation of the terms in the contract must occur

1. Items not supplied, supplied but of substandard quality, or not supplied until long after a deadline
2. Party required to provide an equivalent value previously offered
3. Inability to fulfill contract is under ethical and legal imperative to do everything possible to provide equivalent value to other party

Engineering Ethics and Legal Issues

- The Letter vs. Spirit of the Law

"Read between the lines" in terms of the intent of those documents as understood by those who formulated them"

ASME Code of Ethics of Engineers – Fundamental Principles

Engineers uphold and advance the integrity, honor, and dignity of the Engineering profession by:

- using their knowledge and skill for the enhancement of human welfare;
- being honest and impartial, and serving with fidelity the public, their employers and clients,
- striving to increase the competence and prestige of the engineering profession.

ASME Code of Ethics of Engineers – Fundamental Canons (1)

- Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.
- Engineers shall perform services only in the areas of their competence.
- Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional development of those engineers under their supervision.

ASME Code of Ethics of Engineers – Fundamental Canons (2)

- Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.
- Engineers shall build their professional reputations on the merit of their services and shall not compete unfairly with others.
- Engineers shall associate only with reputable persons or organizations.
- Engineers shall issue public statements only in an objective and truthful manner.

Group Exercise

- Each group is given 10 minutes to discuss and prepare solutions in Powerpoint, and 10 minutes for presentation to class and Q&A
  - Group 1: Case 1 (15.3)
  - Group 2: Case 2 (15.4)
  - Group 3: Case 3 (15.6)
  - Group 4: Case 4 (15.7)
- Cases are designed as problems for you, so seek resolutions that you personally can live with.

Case 1

Newly hired as a production engineer, you find a potential problem on the shop floor: workers are routinely ignoring some of the government mandated safety regulations governing the presses and stamping machines.

The workers override the safety features such as guards designed to make it impossible to insert a hand or arm into a machine. Or they rig up "convenience" controls so they can operate a machine while close to it, instead of using approved safety switches, etc., which requires more movement or operational steps. Their reason (or excuse) is that if the safety features were strictly followed then production would be very difficult, tiring and inefficient. They feel that their shortcut still provides adequately safe operation with improved efficiency and worker satisfaction.

Should you immediately insist on full compliance with all the safety regulations, or do the workers have enough of a case so that you would be tempted to ignore the safety violations? And if you're tempted to ignore the violations, how would you justify doing so to your boss?

Also, how much weight should you give to the workers' clear preference for not following the regulations: ethically, can safety standards be relaxed if those to whom they apply want them to be relaxed?

Case 2

You and an engineer colleague work closely on designing and implementing procedures for the proper disposal of various waste materials in an industrial plant. He is responsible for liquid wastes, which are discharged into local rivers.

During ongoing discussions with your colleague, you notice that he is habitually allowing levels of some toxic liquid waste chemicals, which are slightly higher than levels permitted by the law of those chemicals. You tell him that you have noticed this, but he replies that, since the levels are only slightly above the legal limits, any ethical or safety issues are trivial in this case, and not worth the trouble and expense to correct them.

Do you agree with your colleague? If not, should you attempt to get him to correct the excess levels, or is this none of your business since it is he rather than you who is responsible for liquid wastes?

If he refuses to correct the problems, should you report this to your boss or higher management? And if no one in your company will do anything about the problem, should you be prepared to go over their heads and report the problem directly to government inspectors or regulators? Or should one do that only in a case where a much more serious risk to public health and safety involved?

Case 3

Your company has for some time supplied prefabricated wall sections, which you designed, to construction companies. Suddenly one day a new idea occurs to you about how these might be fabricated more cheaply using composites of recycled waste materials.

Pilot runs for the new fabrication technique are very successful, so it is decided to entirely switch over to the new technique on all future production runs for the prefabricated sections. But there are managerial debates about how, or even whether, to inform the customers about the fabrication changes.

The supply contracts were written with specifications and functional terms, so that love bearing capacities and longevity, etc., of the wall sections were specified, but no specific materials or fabrication techniques were identified in the contracts. Thus it would be possible to make the changeover without any violation of the ongoing contracts with the customers.

On the other hand, since there is significant cost savings in the new fabrication method, does your company have an ethical obligation to inform the customers of this, and perhaps even to renegotiate supply at reduced cost, so that the customers also share in benefits of the new technique? More specifically, do you have any special duty, as a professional engineer and designer of the new technique, to be an advocate in your company for the position that customers should be fully informed of the new technique and the associated cost savings?

Case 4

Your company manufactures security systems. Up to now these have raised few ethical problems, since your products were confined to traditional forms of security, using armed guards, locks, reinforced alloys which are hard to cut or drill, and similar methods.

However, as a design engineer you realize that this modern technology much more comprehensive security packages could be provided to your customers. These could also include extensive video and audio surveillance equipment, along with biometric monitoring devices of employees or other personnel seeking entry to secure areas which would make use of highly personal data such as a person's fingerprints, or retinal or voice patterns.

But there is a problem to be considered. A literature search reveals that there are many ethical concerns about the collection and use of such personal data. For example, these high-tech forms of surveillance could easily become a form of spying, carried out without the knowledge of employees and violating their privacy. Or the data collected for security reasons could easily be sold or otherwise used outside legitimate workplace contexts by unscrupulous customers of your surveillance systems.

Your boss wants you to include as much of this advanced technology as possible in future systems, because customers like these new features and are willing to pay well for them.

However, you are concerned about the ethical issues involved in making these new technologies available. As an engineer, do you have any ethical responsibility to not include any such ethically questionable technologies in products which you design and sell, or to include them only in forms which are difficult to misuse? Or is the misuse of such technologies an ethical problem only for the customers who are buying your equipment, rather than it being your ethical responsibility as an engineer?

Lecture Recap, Homework, and Next Lecture

- Ethics is generally concerned with rules or guidelines for morals and/or socially approved conduct
- Ethical standards generally apply to conduct that can or does have a substantial effect on people's lives

- Assignments: 15.1,15.2,15.5,15.10

References

- CSUN ME Senior Design Lecture notes
- Engineering Your Future, A Comprehensive Approach, Sixth Edition, by Oakes, Leone, Gunn. Publisher: Great Lake Press
- http://www.asme.org/Education/PreCollege/TeacherResources/Code_Ethics_Engineers.cfm