MECH 350
Engineering Design I

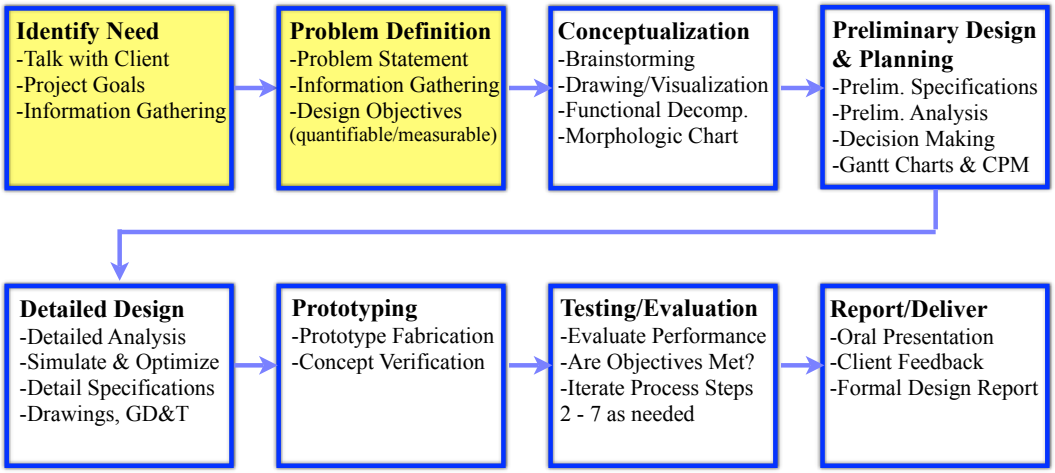
University of Victoria
Dept. of Mechanical Engineering

Lecture 2:
Problem Formulation

Outline:

- NEED STATEMENT
- GOAL STATEMENT
- OBJECTIVES & CONSTRAINTS
- DEVELOPING AND ORGANIZING CRITERIA
- EXAMPLE OF PROBLEM FORMULATION
- GATHERING INFORMATION

The "General" Design Process Model



Problem Formulation

- **Format for the Need Statement:**
  - "Articulate the need as an expression of dissatisfaction with the current situation"
- Example: _____
- Example: _____

Problem Formulation

- **Recognizing the Need**:
  - Identifying the Client:
    - Do we know who this is?
      - _____
    - Do they know what their "need" is?
      - _____
  - Gathering the Client Needs:
    - Interviews
    - Questionnaires
    - Focus Groups
    - Be the customer

Problem Formulation

- **Recognizing the Need**:
  - Rules for interacting with the Client:
    - Keep a broad perspective
    - The client may communicate/pose a 'potential solution', and not their 'true/original need'. Hence, as a designer, you may lose scope of that need, and head in the wrong direction from the start.
    - Always ask "Why", when someone says "I need ..."

Problem Formulation

- **Defining the Goal**:
- Goal Statement:
  - "A goal statement is a brief, general, and ideal response to the need statement"
- Example: _____
- Example: _____
- Carefully consider the scope/boundaries of the Goal Statement

Problem Formulation

- The problem formulation step is a "critical step" in the design process, as well as a clear statement of "Needs" and "Goals".
- Failure to define the need statement & goal statement will almost certainly lead to a design failure.
- Example: _____Solutions looking for Needs_____

Problem Formulation

- Format for the **Need Statement**:
  - "Articulate the need as an expression of dissatisfaction with the current situation"

- Format for the **Goal Statement**:
  - "A goal statement is a brief, general, and ideal response to the need statement"

- Example from Textbook on 'Automobile Bumper':
- Need: *There is too much damage to bumpers in low-speed collisions*.
- Goal: *Design an improved automobile bumper.*

Example 1: Formulation of Need/Goal

- Consider the following client requests:
  - Example #1a:
  - Your client asks you to design a new type of window that has higher insulative properties. Describe a plausible "need" that might have triggered that request. Then identify two fundamentally different goals for designs that can satisfy that need, other than a window with a higher insulation value.

  - Example #1b:
  - Your client asks you to design car tires that have a better grip on the road. Describe a plausible "need" that might have triggered that request. Then identify two fundamentally different goals for designs that can satisfy that need, other than designing tires with better road grip.

Design Objectives

- Definition of "**Design Objectives**"
  - Design Objectives are "quantifiable expectations of performance" that you aim for, or try to achieve.
  - Identify performance characteristics that are of most interest to the client.
  - Describe those characteristics in a way 'you and the client' can 'decide' if the design meets expectations.
  - Describe the conditions under which a design will operate

- Example from Textbook on 'Automobile Bumper':
- Objective: "*Design an inexpensive front bumper so the car can withstand a 5-mph head on collision with a fixed concrete wall without significantly damaging the bumper or other parts of the car, or making the car inoperative. In addition, at the end of the useful life of the bumper, the bumper must be easily recyclable.*"

Design Objectives

- Design Objectives (can be written as constraints):
  - Constraints are "design objectives to avoid or steer away from"
  - Constraints define:
    - the permissible range/scope of the design
    - the quantifiable performance values to avoid/not exceed.
  - Yes-No Constraints
  - Equality Constraints
  - One Sided Inequality Constraints
  - Two Sided Inequality Constraints

Organizing Design Objectives

- Developing and organizing Design Objectives:
  - List all Design Objectives in "short form" in left column.
  - Define "Units" used to quantify the design performance.
  - Define "Target Value/Range" performance targets which correspond to client statement, need and goals, and information from literature. Below table, justify each target value/range.

Design Objective	Units	Target Value/Range
Inexpensive to manufacture	dollars	$1000 - $1100
No damage to bumper in low-speed collision	mm	3 - 5 mm
No damage to other parts of vehicle	dollars	< $50
Easily Recyclable	dollars	$50 - $100
Retain maneuverability of steering after collision	see scale	Good
Retain braking capability	feet	100 feet

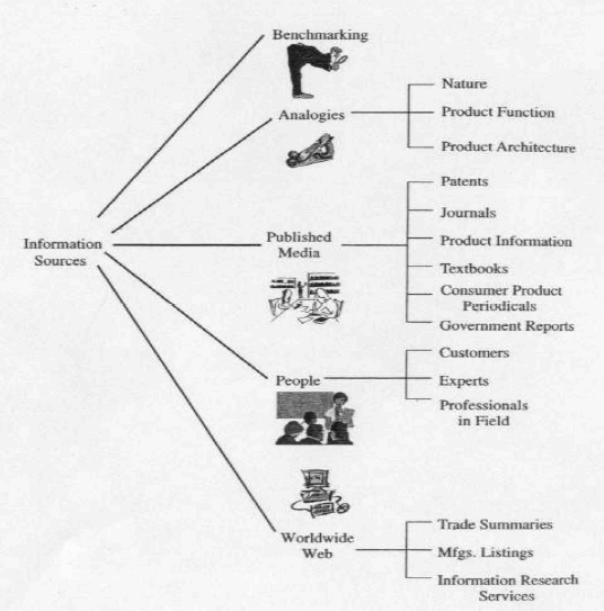
Example 1: Design Objectives

- Develop and organize the Design Objectives for:
  - Project: _____
  - Need: _____
  - Goal: _____

- Table of Design Objectives:

	Design Objective	Units	Target Value/Range
1			
2			
3			
4			
5			
6			

Information Gathering



Information Gathering: Clients and Stakeholders

- Client:
  - The person/group that has commissioned the work or design.
- Stakeholders:
  - Other parties that are affected or impacted by the work or design.
  - _____
- Experts/Professionals:
  - Persons with specific expertise/experience related to work or design.
- Advantages: _____
- Disadvantages: _____

Information Gathering: Published Materials

- Professional Association Magazines and Articles: Examples
  - ASME (http://www.asme.org/kb/news-articles)
  - SAE (Society of Automotive Engineers, http://www.sae.org/pubs/)
  - IEEE (https://www.ieee.org/publications_standards/index.html)
  - SPIE (http://spiedigitallibrary.org)
- Technology Magazines and Articles: Examples
  - IEEE Spectrum (http://spectrum.ieee.org)
  - New Scientist (http://www.newscientist.com/section/tech)
  - MIT Technology Review (http://www.technologyreview.com)
  - Popular Mechanics (http://www.popularmechanics.com)
- Advantages: _____
- Disadvantages: _____

Information Gathering: Published Materials

- Textbooks:
  - UVic Library
  - Local Community Library
- Journal or Conference Papers:
  - Compendex (http://www.engineeringvillage.com)
  - PubMed (http://www.ncbi.nlm.nih.gov/pubmed)
  - Google Scholar (http://scholar.google.com)
- Patents: (http://www.cipo.ic.gc.ca) (http://www.uspto.gov)
- Advantages: _____
- Disadvantages: _____

Information Gathering: The Internet

- News-based websites:
- Professional/Association Community and Forum websites:
- Search Engine Sites (Google, Yahoo, Bing, etc...):
- Advantages: _____
- Disadvantages: _____

Information Gathering: Referencing

- Reference all your materials in your reports!
- There is a correct way to reference materials. A commonly used standard for engineering (suggested for MECH350):
  - http://www.ieee.org/documents/ieeecitationref.pdf
- Many other standards also exist. An overview of all reference standards can be found at: http://en.wikipedia.org/wiki/Citation

Design Example 2: The Fingernail Clipper

- You have recently been hired by Designs-R-Us company, as a product design engineer. The first project assigned to you, is to design a "better fingernail clipper".

- Your first step, is to determine the "Need" and define a "Goal":

- To help you define these, you
  - Do some initial research and information gathering:

    _____
  - Ask some technical questions:

    _____

Design Example: Fingernail Clipper Technical Questions:

- What is the problem or current dissatisfaction all about?
  - Clumsy operation of a typical clipper

- What implicit expectations and desires are involved?
  - Remain a manual clipper
  - Can be operated with one hand
  - _____

- Are the client needs, functional requirements, and constraints truly appropriate?
  - Many groups, as documented in trade magazines and consumer studies, have noted clumsy operation.

Design Example: Fingernail Clipper
Technical Questions:

- What are the characteristics/properties required? (i.e. these are your Design Objectives)
  - Easy to use. Durable. Safe. Portable and compact. Others . . .?
- Are there any restrictions or limitations on the scope? (i.e. these are your Constraints)
  - No electrical power. No service-based solutions. Not Bulky.

- What other aspects should be investigated & quantified now?
  - Customer needs and analysis
  - Fingernail characteristics, such as size and strength
  - Human hand and finger sizes and strengths
- What are the main design conflicts inherent in this design?
  - Compact size vs. large surface area to grasp to create high force

Design Example: Fingernail Clipper

- Format for the Need Statement:
  - "Articulate the need as an expression of dissatisfaction with the current situation"

- Format for the Goal Statement:
  - "A goal statement is a brief, general, and ideal response to the need statement"

- Therefore, for the Fingernail Clipper we can define:
- Need: _____
  _____
- Goal: _____
  _____

Design Example: Fingernail Clipper

- Table of Design Objectives for Fingernail Clipper:

	Design Objective	Units	Target Value/Range
1			
2			
3			
4			
5			
6			