Overview of Design Tools

- Each Stage of the design process is aided by a number of design tools or methods.
- Design teams need to manage team dynamics and the project, and do so in a professional and ethical manner. (Ch. 15, 16, 17)

Design Tools/Methods

Pre-Stage 1: Understanding then detailing client's requirements.

Problem Definition: Detailing Customer Requirements (Ch. 3)

- Clarifying the client statement (Sec. 3.1)

- Framing customer requirements (Sec. 3.2)

- Revising the problem statement (Sec. 3.3)

    - Why clarifying client's statement? (Sec. 3.1)
      Initial client statement is typically given verbally, brief and lacking details;
    - Initial client statement may contain errors, show biases or implied solutions.

      Errors: incorrect information., incomplete data, even mistakes regarding the nature of the problem;

      Biases; inaccurate presumptions due to the client's lack of grasp of the entire problem:

      Implied Solutions: client's best guess at the answer;
      Implied solutions offer insight into client's thinking but restrict the freedom that engineers may otherwise have in search of solutions(s).
      Implied solutions may not solve the problem.

- The lesson is that we must carefully examine initial client statement so as to identify errors, biases and implied solutions.

- Framing customer requirements (Sec 3.2)

  Shifting from the general notion of client's wants towards the specifics of objectives, constraints and functions.

  Objectives are features of behaviors that the design should possess. They are typically expressed in natural languages, as adjectives capturing what the design should *be;*

  Functions are specific things that the design is expected to do. They are typically expressed asa verb-noun combinations, indicating what the design should *do*;

  Constraints are limits/restrictions on the design's behaviours. They can be expressed in a binary (Yes-or-No) fashion.

- List of design attributes

  See table 3.1.

Characteristics	O (Objectives)	C (Constraints)	F (Functions)	M (Means?)
Ladder should be useful				
Used to string conduit and wire in ceilings				
Used to maintain and repair outlets in high places				
Used to place light bulbs and fixtures				
Used outdoors on ground level				
Used suspended from something in some cases				

- Revising the problem statement (Sec. 3.3)
  The revised problem statement is to capture the fuller/newer understanding of the design problem.
  It is also the basis of team charter.
- For example, initial client statement is,
  "Design a safe ladder"

  The revised problem statement could be,
  "Design a new ladder for electricians or other maintenance and construction workers for uses at conventional job sites."

- Pareto Principle (aka the 80/20 rule):

  80% of the cost and quality of a product are determined by the decisions made in the first 20% of the product development process.

  In other words, it is much more expensive to recover from errors that occur early in the design process. So the most important design decisions are the early ones.

Stage 1 – Design Tools:

- Objectives tree (Sec. 4.1.1)
- Pairwise comparison chart (Sec. 4.3)
- Metrics to measure the achievement of objectives (Sec 4.4)
- Etc.

Problem Definition: Clarifying the Objectives (Ch. 4)

- Clarifying client's objectives by Objective Tree (Sec 4.1)
- Rank-ordering objectives by Pairwise Comparison Chart (Sec. 4.3)
- Measuring the achievement of objective by Metrics (Sec. 4.2 & 4.4)
- Clarifying client's objectives by Objective Tree (Sec. 4.1)

  Typically, we start with a list of objectives (see Table 4.1 for example; this list can be extracted off the Lists of design attributes, see Table 3.1 for example); we then organize or group the objectives so that there are some hierarchies.

  Objective Tree is a graphical representation of the hierarchy of design objectives, see Figs. 4.1 and 4.2.

- Reference to the "personal mobility device to transport people unable to use their legs" project from Week 1.
- Use Objective Tree to identify objectives
  - Safe is always a top-level objective
- Objective tree drawn on board for Ladder
  - Safe
    - Sturdy
    - Slip-resistant
      - Steps
      - Feet
  - Marketable
    - Multi-purpose
    - Inexpensive
    - Portable
    - Durable
- Rank-ordering objectives by PCC – Pairwise Comparison Chart (Sec. 4.3)

  Objectives are not equally important; Or they are not of the same value to the client of user(s).

  PCC is a means to measure the objectives' relative values.

  PCC is applied to objectives under the same grouping and at the same level.

  Individual PCC for a ladder design

  Between Objectives A and B:
  0.5 if A and B are equal important;

1 for A and 0 for B is A is more important;
0 for A and 1 for B is B is more important;

Objectives	Cost	Portability	Usefulness	Durability	Score
Cost	-	1	0	0.5	1.5
Portability	0	-	0	1	1
Usefulness	1	1	-	0	2
Durability	0.5	0	1	-	1.5

- Aggregate PCC for a ladder design

Objectives	Members				Score
	X	Y	Z	W	
Cost					
Portability					
Usefulness					
Durability					

- A few notes regarding PCC

Objectives are compared only at the same level and under the same grouping;

Higher objectives should be compared/ranked before those at lower level;

PCC ranking can be subjective;

Ranking relative; a zero score does not imply that the objective in question is not important

Reading assignment:
Ch. 3 (S. 3.1, 3.2, 3.3)
Ch. 4 (S. 4.1)