ENGR 310

Lecture 20
4 April 2008

Exam: April 7

- Closed book, closed journal, closed neighbor, open mind
- 4" x 6" reference card allowed
- Timed
- Short Answer questions
- Covers the course learning objectives
  - www.coe.montana.edu/engr310

What is Engineering Design?

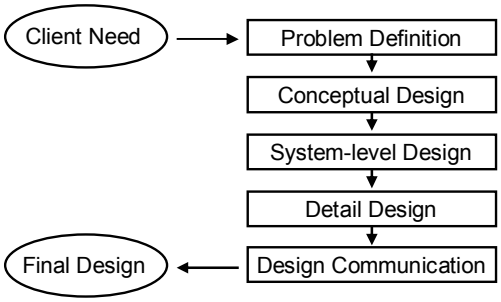
"…systematic, intelligent generation and evaluation of specifications for artifacts whose form and function achieve stated objectives and satisfy constraints."

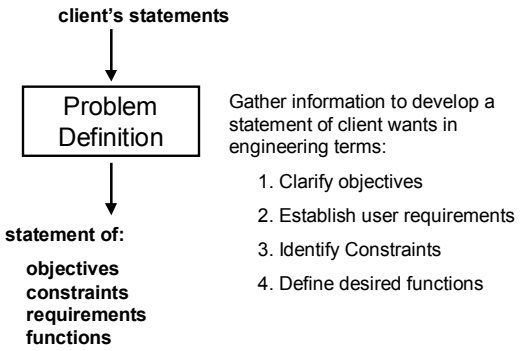
-Dym & Little, 2004

Design in Engineering is:

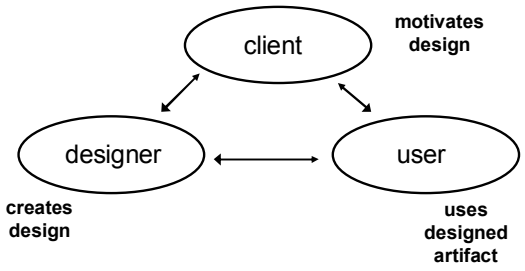
- Ill-structured → cannot apply a formula
- Open-ended → >1 solution possible
- Complex
- Must integrate many pieces.
- Must integrate with environment

An Engineering Design Process

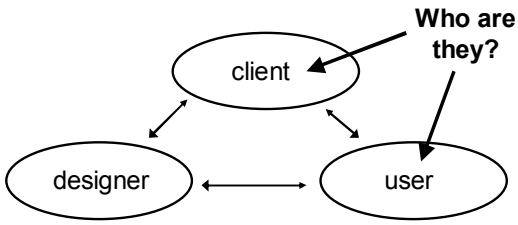




Who Sets Objectives and Constraints?



First step



Clarify the Design Problem

Observation
Interviews
Researching existing solutions

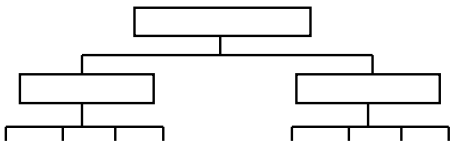
→ Comprehensive list of desired characteristics

Most initial attribute lists are a mix of:

- Objectives
- Constraints
- Functions
- Means (or implementations)

Objective Tree

Helpful to organize objectives into a hierarchy.



Add Constraints (but differentiate).
No functions or means!

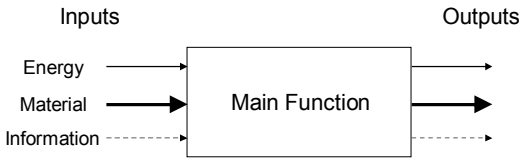
Functions & Specifications

Functions = what system must do to achieve objectives

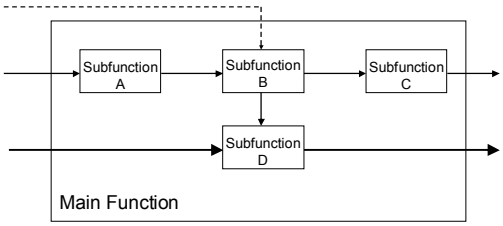
Functional Specifications = how well system must do it

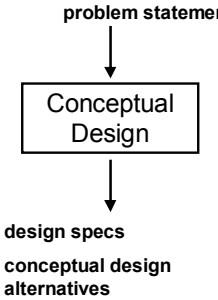
Also called “performance specifications” or “functional requirements”

Black Box Approach



Divide Functions into Subfunctions





Generate concepts of candidate designs:

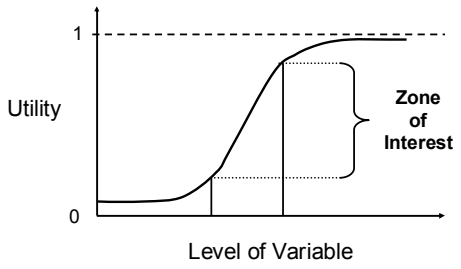
5. Establish design specifications
6. Generate ideas

Functional Specifications

How well must the design accomplish the functions?

- Measurable
- Solution neutral
- Things client/users care about

"Zone of Interest"



Common Mental Blocks

- Perceptual: define problem too narrowly
- Fixation: can't get past one idea
- Emotional: anxiety, fear of failure, frustration
- Cultural: social patterns that blind us to possible solutions
- Environmental: distractions, poor atmosphere

Conceptual Blockbusting

- First step is to recognize them.
- Second, use structured techniques to break out of your current thinking pattern

Where do new ideas come from?

- Adaptations of existing ideas to new contexts
  - Generalize the problem, look for others' solutions
- Combining existing ideas
- Analogy

Technique 1: Brainstorming

- List all ideas
  - individually first, then as a group
- No criticism or evaluation!
  - encourage crazy, outlandish ideas
  - have fun!!

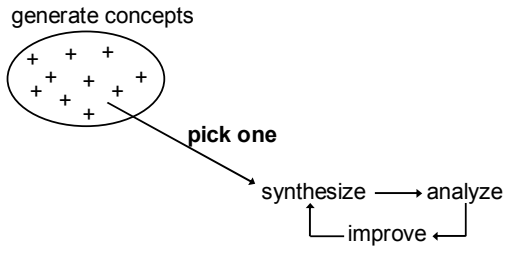
Technique 2: Morphological Chart

	1	2	3	4
Accept Beans	Lid	Door	Gravity chute	…
Contain Beans	Canister	Bag	Vacuum	…
Grind Beans	Rotating blade	Mortar & pestle	Opposing discs	…
Etc.				

Technique 3: Group Brain-writing

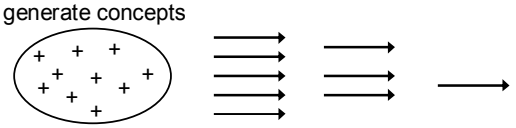
1. Decide on problem to be addressed
2. Silently, each person generates 3 ideas.
   1. Sketches + labels (minimum of words)
3. Rotate ideas to person on the right.
4. Build on the ideas just passed to you
   1. for a set period of time.
5. Repeat until ideas reach originator.
6. Review, discuss, evaluate, combine.
   1. post on the wall
7. Choose a subset to carry forward.

"Pick Best and Iterate" Approach



"Controlled Convergence" Approach

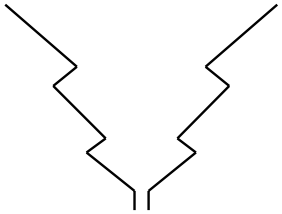
generate concepts



Look at sets of design ideas…

…and eliminate the worst.
(rather than pick the best)

Design Convergence…



…isn't usually smooth.

Evaluation Matrix

Criteria	Alternatives A	B	C
a)			
b)			
c)			
d)			

specs + design alt's

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System-level Design

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system architecture

Identify principle attributes of leading design concepts:

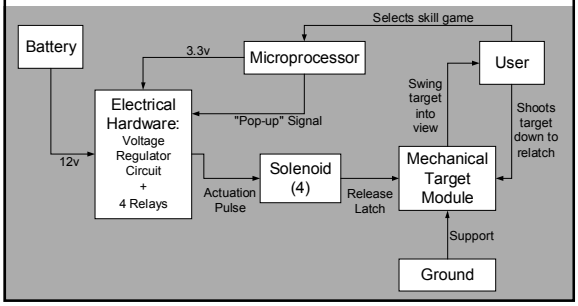
7. Establish system architecture
8. Model and evaluate alternatives
9. Converge to best alternative

System-level Design

- Identify subsystems of the concept
- Investigate alternative configurations
- Think through interface issues, in detail
  - between subsystems
  - with user
  - with environment
- Choose configuration based on the best interfaces

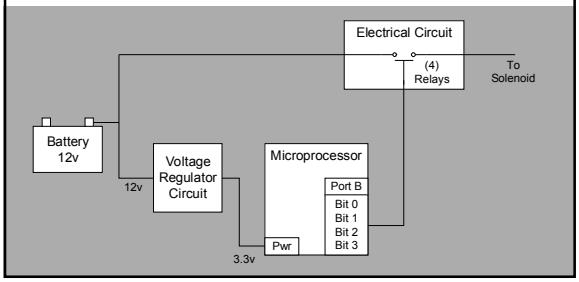
Block Diagram

- Identifies key subsystems and interfaces



System Architecture Plan

- Adds interface details to block diagram



system architecture

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Detail Design

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proposed fabrication specifications

Refine and add detail to final design:

10. Create detailed drawings, etc.
11. Optimize through analysis
12. Review design.

proposed fabrication specifications

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Design Communication

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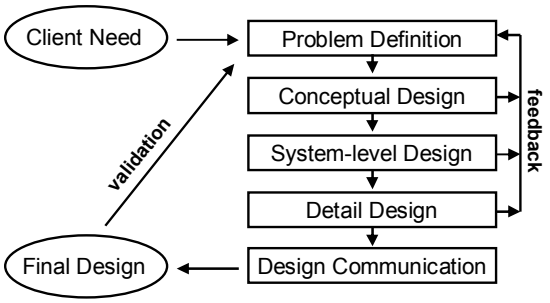
final fabrication specifications

client report

Document fabrication specifications and justification

Iteration



The Process is Not Linear!

- Phases tend to overlap in practice
- Applications repeat on different:
  - subproblems
  - levels of abstraction
- Problem definition tasks appear in some form in each phase

A Project Management Framework

Project Definition

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Project Planning

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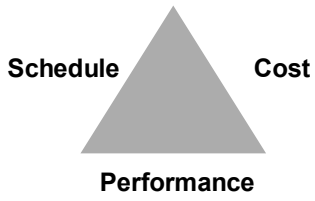
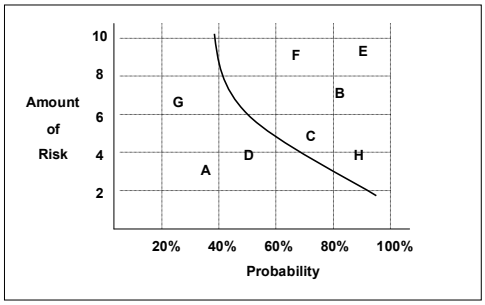
Project Tracking & Control

The Project Triangle

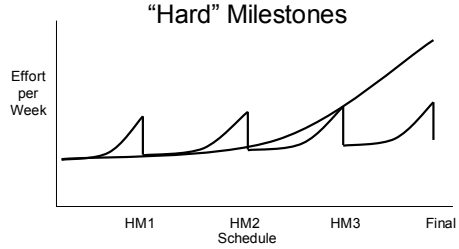


Project Risk Chart



Project Planning Approach

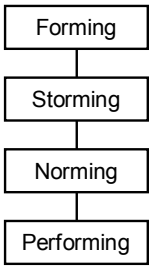
- Project Manager Sets Multiple "Hard" Milestones



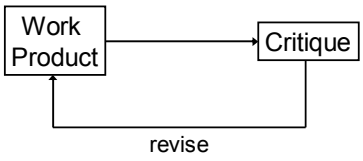
Building the Plan

1. Develop work breakdown structure (WBS)
2. Define length for each task
3. Define dependencies
4. Assign resources
5. Review for over -allocation

Stages of Team Development



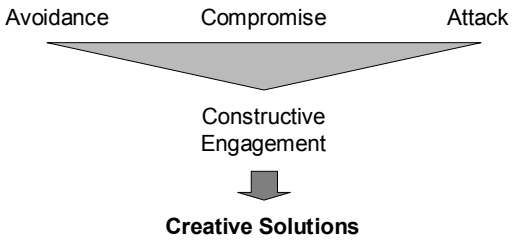
Feedback: An essential element of design reviews



PAUSE Principle

Prepare – get the facts, generate options
Affirm – the relationship
Understand – the others' issues
Seek – mutually beneficial options
Evaluate – Have we satisfied the major concerns?

Conflict Management Strategies



Keys to Effective Meetings

- Prepare ahead of time.
- Have a written agenda.
- Agree on meeting's objectives.
- Start on time.
- Document decisions made.
- Don't leave without an action plan.
- Establish ground rules.
- Appoint a facilitator.

Five Sets of Teamwork Skills

1. Interpersonal communication and collaboration
2. Understanding & communicating trade-offs and empathy for diverse perspectives
3. Planning/organization and accountability/reliability
4. Common goals/shared outcomes and conflict management, resolution
5. Willingness to learn and inclusive decision-making

Why do design projects fail?

1. Misunderstanding what the customer needs.
2. Committing to a solution too early.
3. Lack of teamwork: esp. communication & conflict resolution across disciplines.
4. Poor system architecture, especially interfaces.
5. Poor planning.

Good Luck on Monday!