

Stanford University
School of Engineering

Civil & Environmental Engineering 169

***ENVIRONMENTAL & WATER
RESOURCES ENGINEERING DESIGN***



- **Introduction**
- **Design and the Design Process**



CIVIL & ENVIRONMENTAL ENGINEERING 169
***ENVIRONMENTAL & WATER RESOURCES
ENGINEERING DESIGN***

Spring 2007 - 08
TTh 2:15 - 4:05
Y2E2 164

Website: CourseWork (<http://coursework.stanford.edu>)

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CIVIL & ENVIRONMENTAL ENGINEERING 169
*ENVIRONMENTAL & WATER RESOURCES
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PASTA CANTILEVER DESIGN

- **Goal**
Economic cantilever structure with optimal combination of span and clearance
- **Objective**
Maximize: $\text{Span (cm)} * \text{Clearance (cm)} - 50 * \text{Mass (g)}$
Prototype
Design/construction documents
- **Materials**
453 g uncooked Safeway fettuccine
397 g Brach caramels
- **Constraints**
Support
Initial projection
No reshaping of fettuccine
Time: 50 minutes for design and prototype construction
10 minutes for completion of design drawings



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.

ABET (Accreditation Board for Engineering and Technology)

Engineering design is the systematic, intelligent generation and evaluation of specifications for artifacts whose form and function achieve stated objectives and satisfy specified constraints.

Dym and Levitt, *Knowledge-Based Systems In Engineering*, McGraw-Hill, New York, 1991.

PASTA CANTILEVER DESIGN

- Goals/objectives (needs and wants)

- Characterizing goals

- ◆ Performance
 - Functionality
 - Failure modes
- ◆ Efficiency
 - Economic
 - Resources
- ◆ Sustainability
 - Maintaining total capital
 - Intergenerational equity
- ◆ Uncertainty, risk, and safety
- ◆ Ethical behavior
- ◆ Aesthetic



PASTA CANTILEVER DESIGN

- Goals/objectives (needs and wants)

Who defines them?

How are they articulated?

- ♦ Criteria and constraints
- ♦ Explicitly and implicitly

Multiobjective criteria

- ♦ Trade-offs
- ♦ Optimization

$$S = H(M) * V(M) - 50M$$

$$\frac{\partial S}{\partial M} = V \frac{\partial H}{\partial M} + H \frac{\partial V}{\partial M} - 50$$



PASTA CANTILEVER DESIGN

- Engineering knowledge and analysis

Static equilibrium (stability)

Moments

Compression and tension

Material properties

Dominant failure modes

- Creativity, ideas, and experience

From where do design ideas come?

- ♦ Experience
- ♦ Reasoning from knowledge (analysis and synthesis)
- ♦ Experimentation and testing



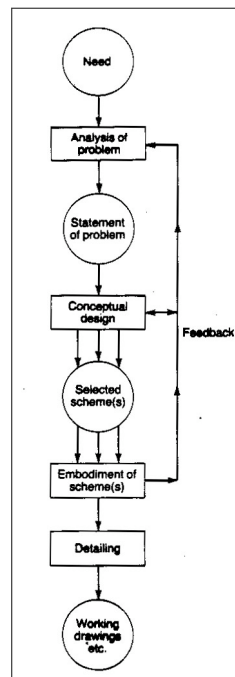
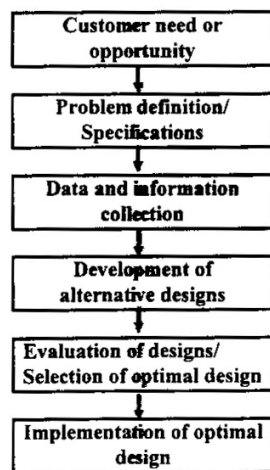
PASTA CANTILEVER DESIGN

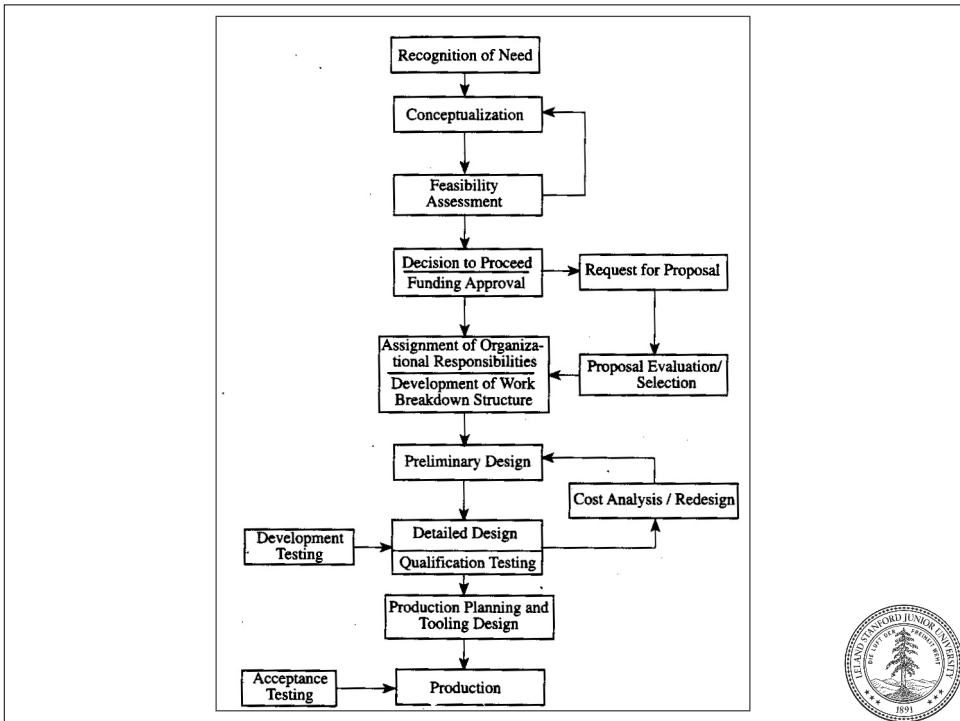
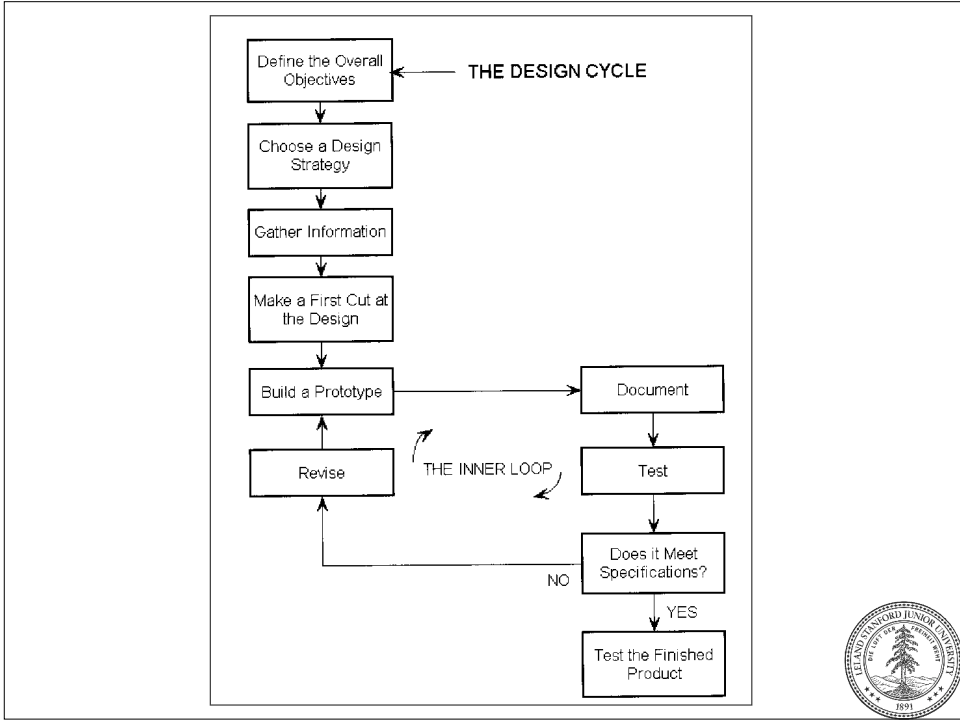
- Manufacturability
- Teamwork
- Design communication
 - Visual
 - Verbal
- Aesthetics and emotion

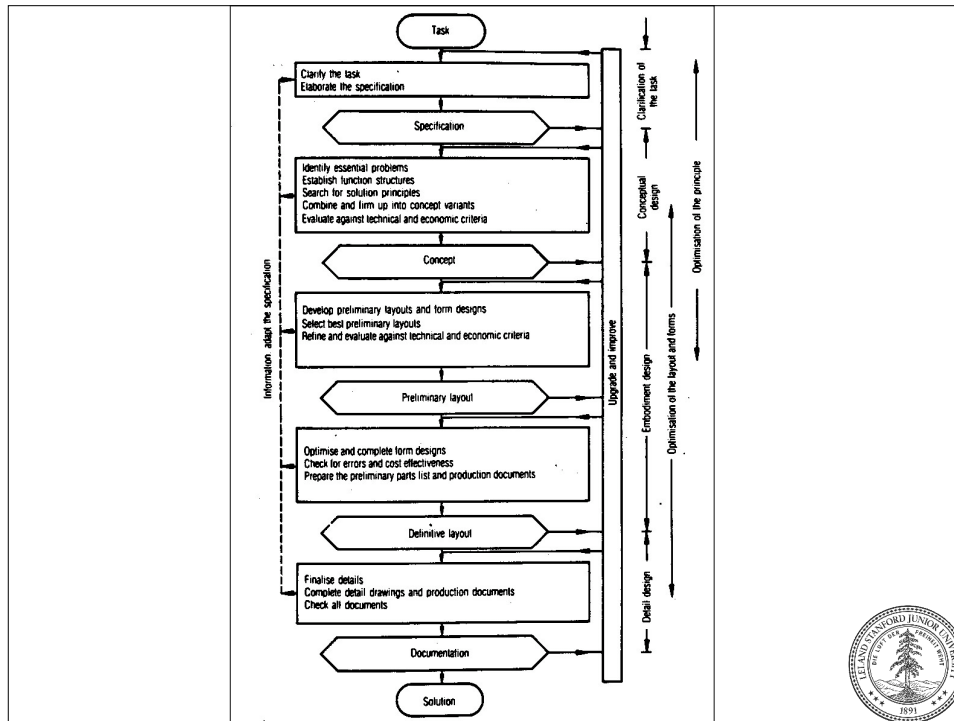


ELEMENTS OF DESIGN

The Engineering Design Process







DESIGN

Engineering refers to the practice of *organizing* the design and construction [and, I would add, operation] of any artifice which transforms the physical world around us to meet some recognized need.

Rogers, G.F.C., cited in Vincenti, Walter G., *What Engineers Know and How They Know It*

From the point of view of modern science, design is nothing, but from the point of view of engineering, design is everything. It represents the purposive adaptation of means to reach a preconceived end, the very essence of engineering.

E.T. Layton, Jr., "American Ideologies of Science and Engineering," *Technology and Culture*, 17(4), Oct. 1976, p. 696

DESIGN

- Craft/Artisanship
- Routine Design
- Variant Design
- Creative or Radical Design



COURSE GOALS

- Knowledge of the process of design
 - Focus
 - ♦ Is *not* on new factual knowledge of the physical world
 - ♦ Is *not* on applying knowledge that you already have
 - ♦ Is on how to learn, understand, organize, make decisions, and communicate
- Design experiences
- Professional engineering design practice
 - Engineering as a sociotechnical enterprise
 - Clients, consultants, and employees
 - Professional ethics
 - Design teams

