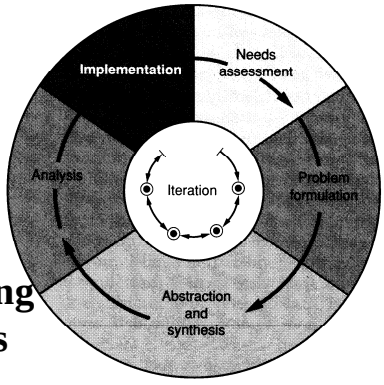
Chapter 3
Engineering Design

Engineering Design is iterative:

You start with an idea, Encounter obstacles, and seek to overcome them until you arrive at the desired product.

1908 Buick

Engineering Design is iterative



Activity Time Schedule

Design Steps	Percentage of Total Time
	10 20 30 40 50 60 70 80 90 100
Identify need	
Define problem	
Search	
Constraints	
Criteria	
Alternatives	
Analysis	
Decision	
Specifications	
Communication	

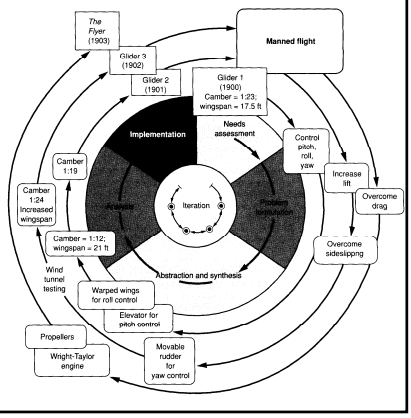
A time schedule must be developed early in order to control the design process.

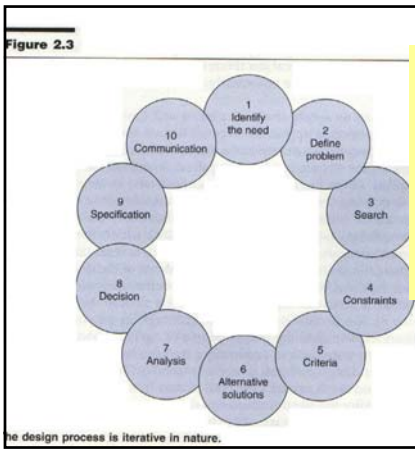
Exemplary engineering: **The Wright Brothers**

Wright Brothers bike shop in Dayton, OH

The Wright Brothers systematically addressed every design problem.

FIGURE 1.5 Complete design process led to the Wright brothers' success.





Design Project Schedule:

structured along Chapter 2 of Textbook

How We Made the First Flight by Orville Wright

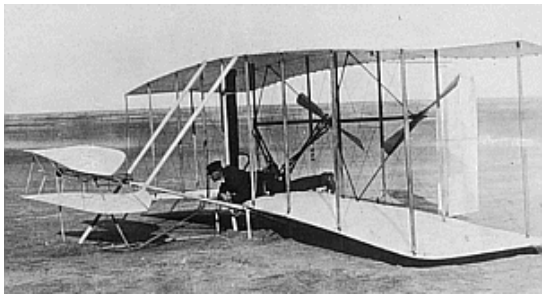
"The flights of the 1902 glider had demonstrated the efficiency of our system for maintaining equilibrium. We felt that we were prepared to calculate in advance the performance of machines. Before leaving camp in 1902 we were already at work on the general design of a new machine which we proposed to propel with a motor. "

How We Made the First Flight by Orville Wright

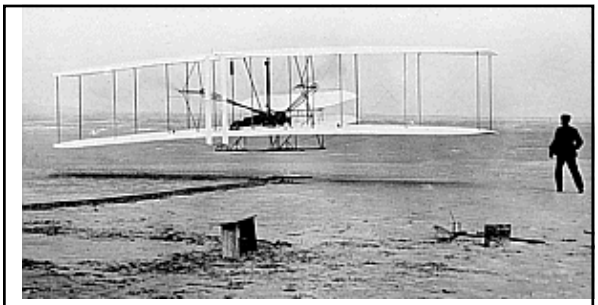
1902 Glider

How We Made the First Flight by Orville Wright

"Immediately upon our return to Dayton, we wrote to a number of automobile and motor builders, asking whether they could furnish one that would develop eight-brake horse power, with a weight complete not exceeding 200 pounds.
Finally we decided to undertake the building of the motor ourselves. "



***The "Flyer" after it's first 3 1/2 second flight,* a failure.**



The first manned flight :
December 17, 1903. At 10:35 a.m.
Orville Wright takes off into a 27 mph wind. The distance covered was 120 feet

MEG 100 Lab

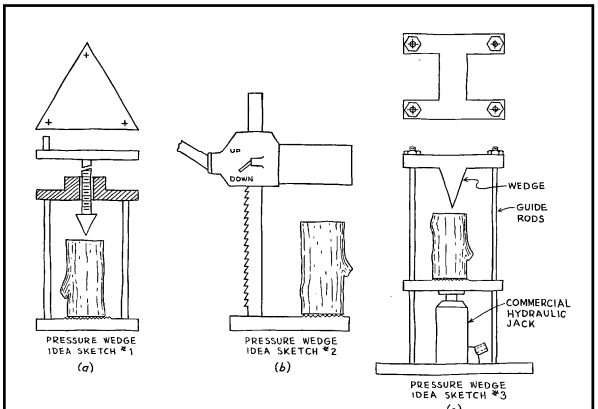
Design Project

Your Assignment:

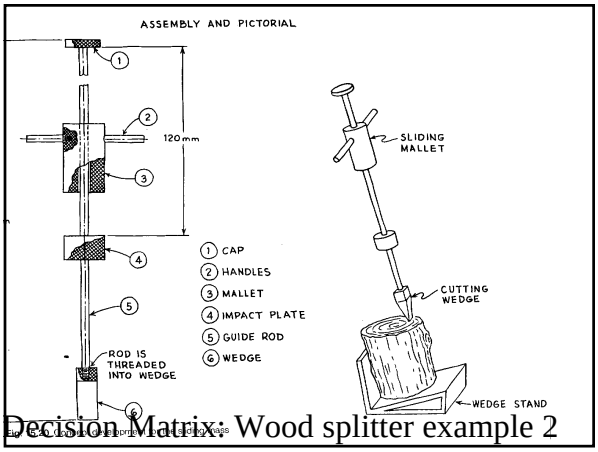
Identify need:

Submit one-page report this week before your lab session to the lab instructor.

Why build an autonomous vehicle?



Decision Matrix: Wood splitter example



Decision Matrix: Wood splitter example 2

Decision Matrix

Decision Matrix

Criteria	Weight W, percent	Selected concepts (see below) 1	2	3	4	5	6
Cost	30	6	7	7	7	9	
		180	210	210	210	270	
Ease of operation	20	10	7	9	10	7	
		200	140	180	200	140	
Safety	15	9	7	6	5	8	
		135	105	90	75	120	
Portability	15	6	5	4	10	10	
		90	75	60	150	150	
Durability	10	8	9	10	9	9	
		80	90	100	90	90	
Use of standard parts	10	7	8	8	6	9	
		70	80	80	60	90	
Total	100	755	700	720	785	860	

Rating scale R: Excellent 9–10; Good 7– 8; Fair 5– 6; Poor 3– 4; Unsatisfactory 0– 2

Rating = R × W / 180

Selected concepts
1. Auto-jack principle (Item # 2)
2. Drop wedge from elevation (Item # 10)
3. Spring-powered wedge (Item # 8)
4. Wedge driven by explosion (Item # 12)
5. Sliding mass (Item # 9)
6. Additional concepts

Fig. 15.23 Each concept was rated on a scale of 0 to 10 for each criterion. The rating was multiplied by the criterion weight and then summed. Concept 5 was chosen as the optimum even though it did not receive the highest rating on three of the six criteria.

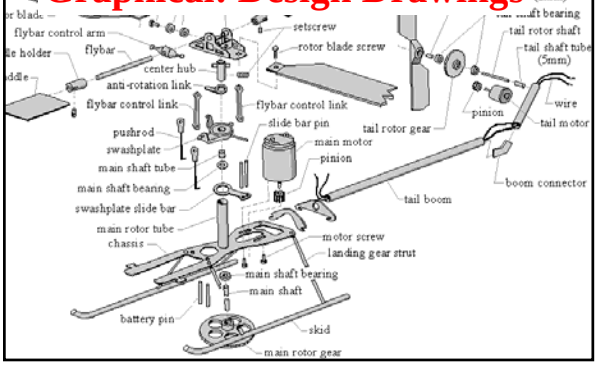
Technical Communication

Graphical

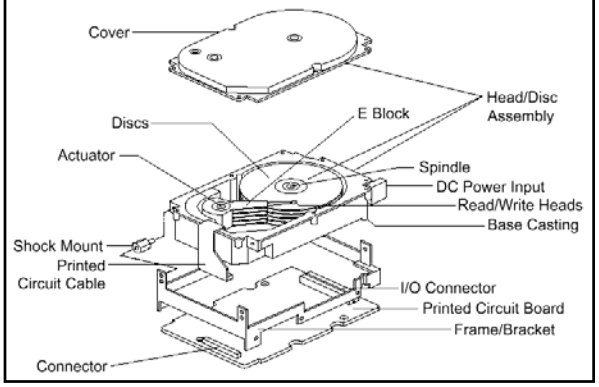
Written and Oral

Technical Communication

Graphical: Design Drawings

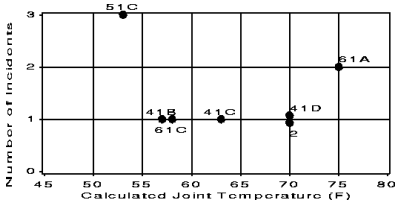


Hard Disk

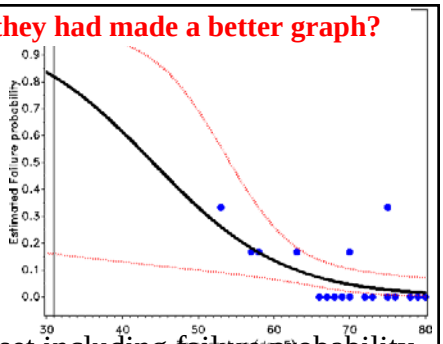


Graphical Analysis and Presentation

Remember the *'inconclusive'* graph about O-rings presented during the Challenger Pre-Launch conference?



What if they had made a better graph?



Same data set including failure probability as function of temperature. **The trend line suggests unacceptable risk**

Technical Communication:

Pattern Recognition

The Cholera Epidemic in London, 1854

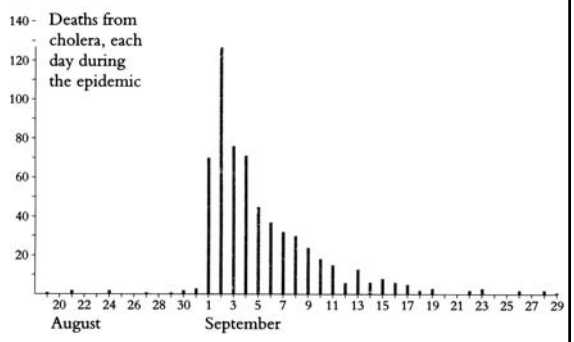
The Cholera Epidemic in London, 1854

Cholera broke out in the Broad Street area of central London on the evening of August 31, 1854. John Snow, who had investigated earlier epidemics, suspected that the water from a community pump-well at Broad and Cambridge Streets was contaminated. When testing the water, Snow saw no suspicious impurities, and thus he hesitated to come to a conclusion. This absence of evidence, however, was not evidence of absence:

The Cholera Epidemic of 1854

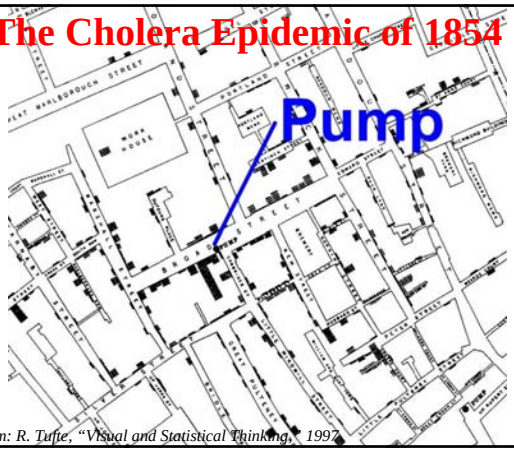
"Further inquiry . . . showed *me* that there was no other circumstance or agent common to the circumscribed locality in which this sudden increase of cholera occurred, and not extending beyond it, except the water of the above mentioned pump. I found, moreover, that the water varied, during the next two days, in the amount of organic impurity, visible to the naked eye, on close inspection, in the form of small white, flocculent [loosely clustered] particles."

The Cholera Epidemic of 1854



From: R. Tufte, "Visual and Statistical Thinking," 1997

The Cholera Epidemic of 1854



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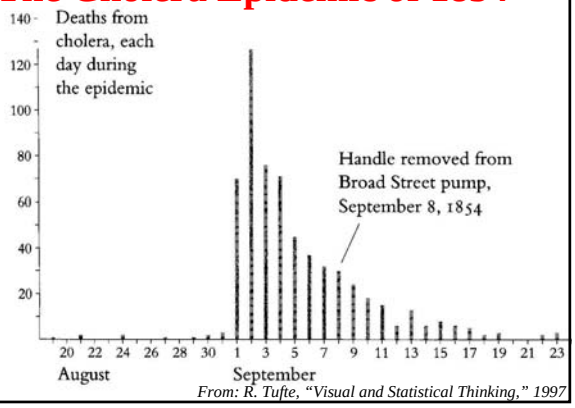
The Cholera Epidemic of 1854

On September 7th, the vestrymen on St. James' were sitting in solemn consultation on the causes of the epidemic. Such a panic possibly never existed in London since the great plague. People fled from their homes as from instant death. During their solemn deliberation, the vestrymen were called to consider a new suggestion. A stranger had asked, in modest speech, for a brief hearing.

The Cholera Epidemic of 1854

Dr. Snow was admitted and in few words explained his view. He had fixed his attention on the Broad Street pump as the source and centre of the calamity. He advised removal of the pump-handle as the grand prescription. The vestry was incredulous, but had the good sense to carry out the advice. The pump-handle was removed, and the plague was stayed.

The Cholera Epidemic of 1854

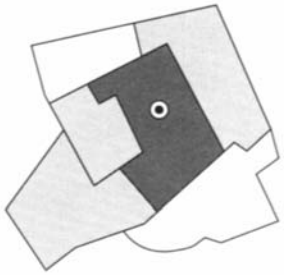


From: R. Tufte, "Visual and Statistical Thinking," 1997

2.11 Technical Communication

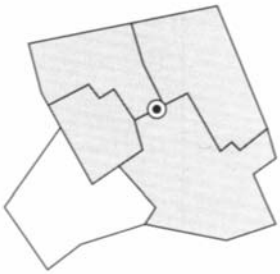
Graphical

How to lie with maps:
Three different ways to plot the same set of data (London Cholera Epidemic)



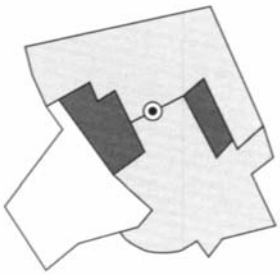
In this aggregation of individual deaths into six areas, the greatest number is concentrated at the Broad Street pump.

From: R. Tufte, "Visual and Statistical Thinking," 1997



Using different geographic subdivisions, the cholera numbers are nearly the same in four of the five areas.

From: R. Tufte, "Visual and Statistical Thinking," 1997



In this aggregation of the deaths, the two areas with the most deaths do not even include the infected pump!

From: R. Tufte, "Visual and Statistical Thinking," 1997

Although we often hear that data speak for themselves, their voices can be soft and sly.

Frederick Mosteller, Stephen B. Fienberg, and Robert E. K. Rourke, *Beginning Statistics with Data Analysis*
(Reading, Massachusetts, 1983), p-234.

Negligent speech doth not only discredit the person of the Speaker, but it discrediteth the opinion of his reason and judgment; it discrediteth the force and uniformity of the matter, and substance.

BenJonson, *Timber: or, Discoveries*
(London, 1641)