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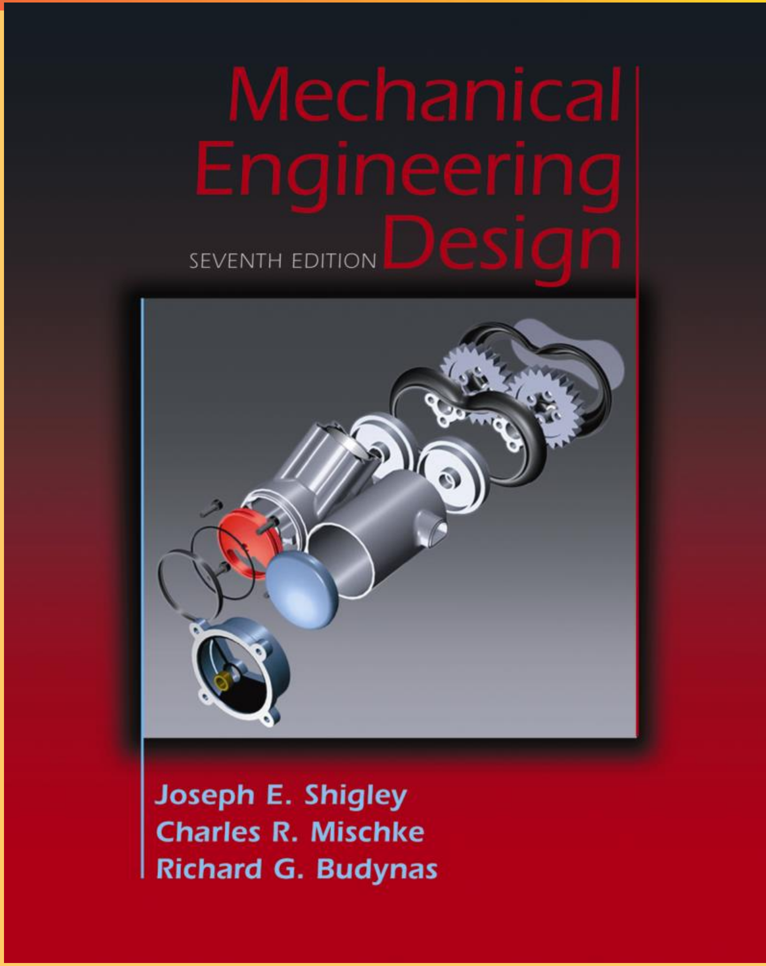
PowerPoint Images

Chapter 1

Introduction



Mechanical Engineering Design

Seventh Edition

Shigley • Mischke • Budynas

A product design must be

- Functional : The product must perform to fill its intended need and customer expectation.

- Safe : The product is not hazardous to the user, bystanders, or surrounding property. Hazards which cannot be “designed out” are eliminated by guarding (a protective enclosure); if that is not possible, appropriate directions or warnings are provided.

- Reliable : Reliability is the conditional probability, at a given confidence level, that the product will perform its intended function satisfactorily or without failure at a given age.

- Competitive : The product is a contender in its market.

- Usable : The product is “user-friendly” accommodating to human size, strength, posture, reach, force, power, and control.

- Manufacturable : The product has been reduced to a “minimum” number of parts, suited to mass production, with dimensions, distorsion, and strength under control.

- Marketable : The product can be bought, and service (repair) is available.

Human & Computer Programs

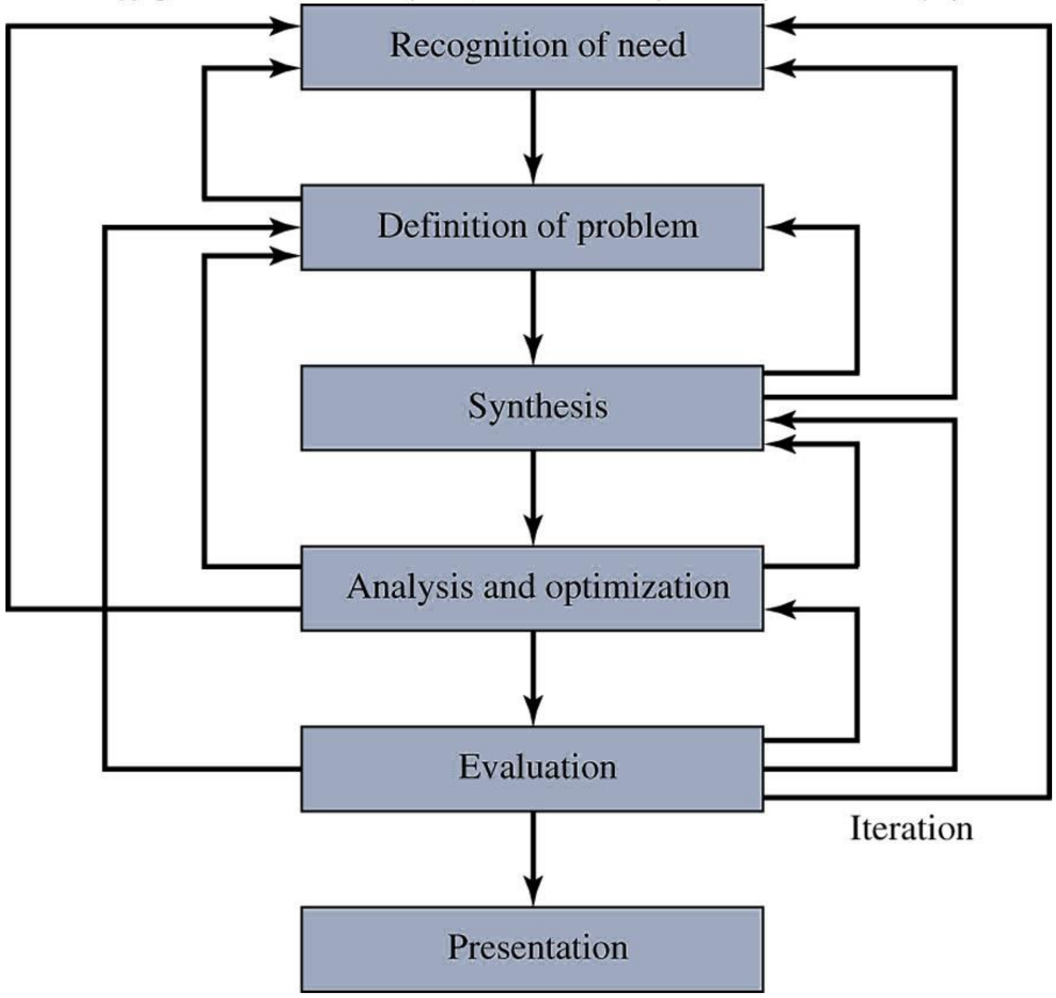
There are many programs – Matlab, Excel, Ansys, Abaqus, AutoCAD, I-DEAS, etc.

You should keep in mind,

- The computer can remember data and programs.
- The computer can calculate.
- The computer can branch conditionally and unconditionally. Branching based on truth or falseness is akin to decision making.
- The computer can iterate, do a repetitive task a fixed or appropriate number of times.
- The computer can read and write both alphabetic and numerical information.
- The computer can draw, sometimes fast enough to animate in real time.
- The computer can pause and wait for external decisions or thoughtful input.
- The computer does not tire.

- Humans can understand the problem.
- Humans can judge what is important or unimportant.
- Humans can plan strategies and modify them in the light of experience.
- Humans can weigh intangibles.
- Humans can be skeptical, suspicious, and unconvinced.
- Humans can program computers !

Interaction Between Design Process Elements



Definition of the problem must include all the specifications for the thing that is to be designed.

The synthesis of a scheme connecting possible system elements is sometimes called the invention of the concept.

Fig.1.3 The phases in design, acknowledging the many feedbacks and iterations

Design Considerations

- Strength/stress
- Distorsion/deflection/stiffness
- Wear
- Corrosion
- Safety
- Reliability
- Friction
- Usability
- Utility
- Cost
- Processing
- Weight
- Life
- Noise
- Styling
- Shape
- Size
- Control
- Thermal properties
- Surface
- Lubrication
- Marketability
- Maintenance
- Volume
- Liability
- Scrapping/recycling

Codes and Standards

A standard is a set of specifications for parts, materials, or processes, intended to achieve uniformity, efficiency, and a specified quality.

A code is a set of specifications for the analysis, design, manufacture, and construction of something.

Economics

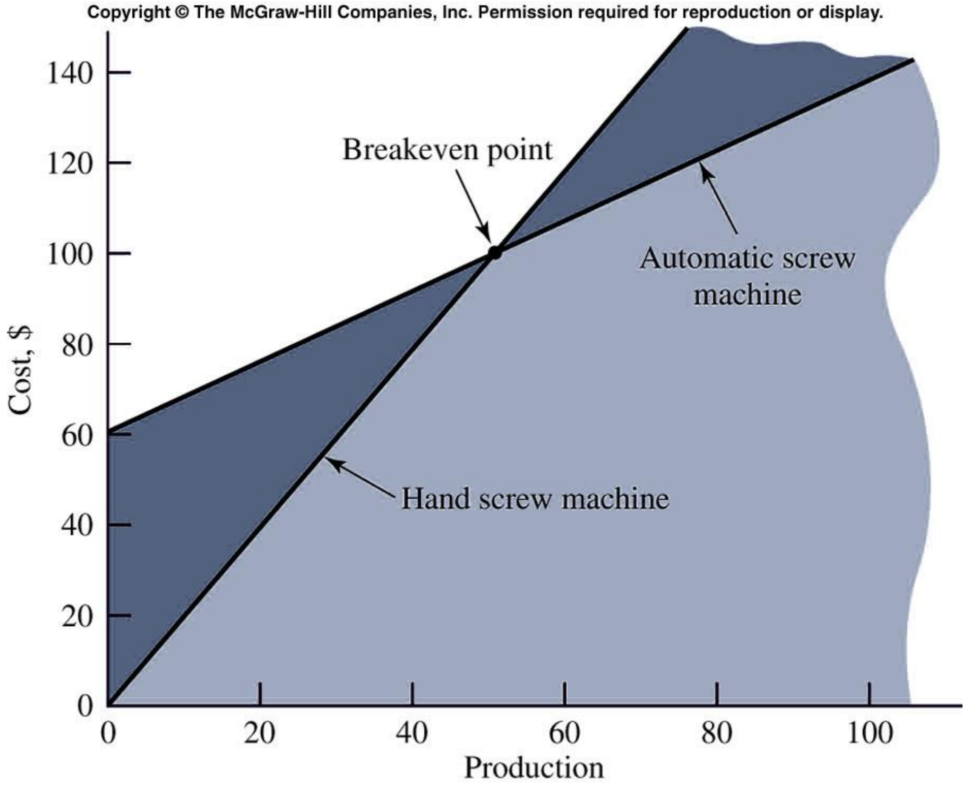


Fig.1.4 A breakeven point.

Standart sizes

The use of standart or stock sizes reduce cost.

Large tolerances

Close tolerances may necessiate additional steps in processing.

Safety and Product Liability

Good engineering in both analysis and design, quality control, and comprehensive testing procedures.

The Adequacy Assesment

Uncertainty

$$n_d = \frac{loss-of-function\ load}{impressed\ load}$$

$$Allowable\ load = \frac{loss-of-function\ load}{n_d}$$

n_d is the design factor

$$\sigma_{all} = \frac{strength}{n_d^m}$$

$$n_d = \frac{S}{\sigma}$$

$$\bar{n}_d = \frac{\bar{S}}{\bar{\sigma}}$$

Stress and Strength

S : strength

S_s : shear strength

S_y : yield strength

S_u : ultimate strength

Tension $0.45\ S_y \le \sigma_{all} \le 0.60\ S_y$

Shear $\tau_{all} = 0.40\ S_y$

Bending $0.60\ S_y \le \sigma_{all} \le 0.75\ S_y$

Bearing $\sigma_{all} = 0.90\ S_y$

Design Factor and Factor of Safety

$$n_d = \left(\frac{strength}{stress} \right)^3$$ for sphere in contact fatigue

$$n_d = \left(\frac{strength}{stress} \right)^2$$ for cylinders in contact fatigue

Reliability

The statistical measure of the probability that a mechanical element will not fail in use is called the reliability of that element.

$$0 \le R < 1$$

Numbers, Units, and Preferred Units

$$F = MLT^{-2}$$

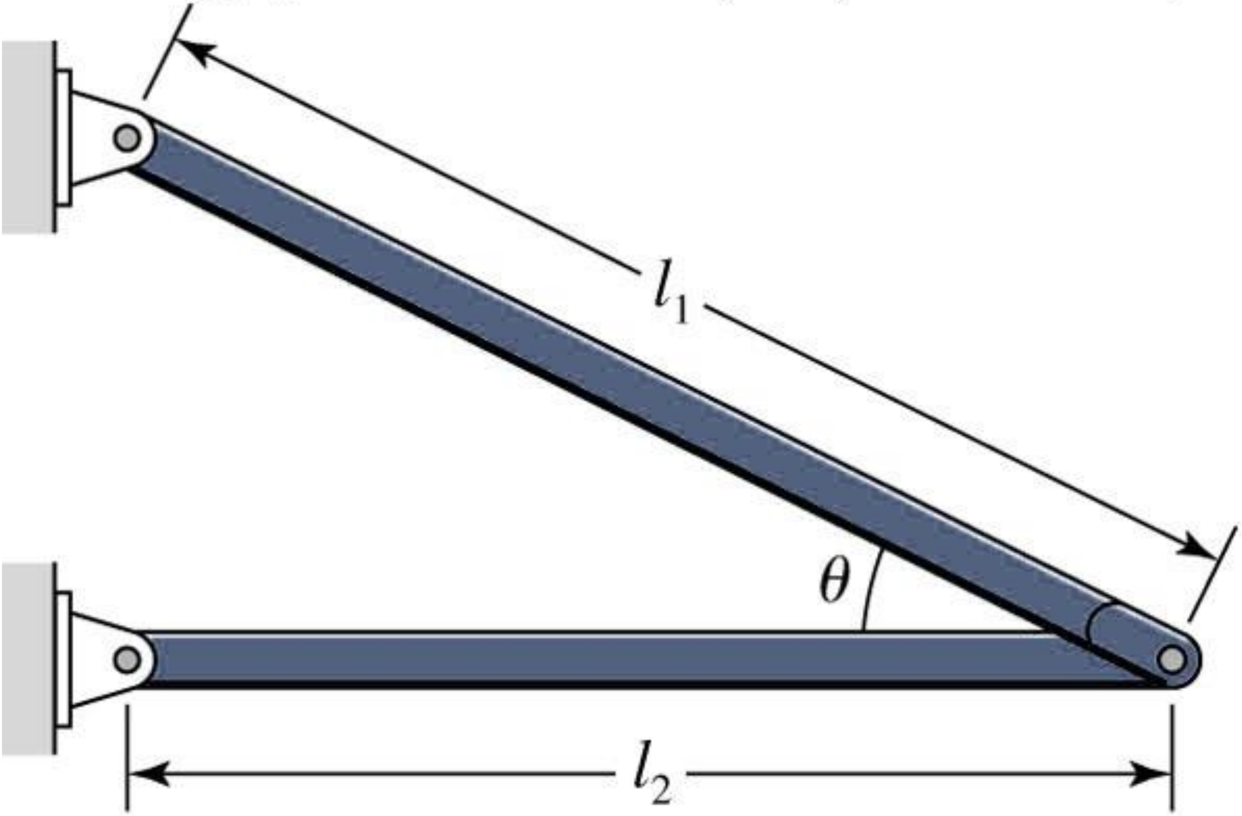
$$M = \frac{FT^2}{L}$$

Chapter 1, Problem 8 (Chapter 1, Problem 10).

The engineering designer must create (invent) the concept and connectivity of the elements that constitute the design, and not lose sight of the need to develop the idea(s) with optimality in mind. A useful figure of merit can be cost, which can be related to the amount of material used (volume or weight). When you think about it, the weight is a function of the geometry and density. When the design is fleshed out, finding the weight is a straightforward, sometimes tedious task. The figure depicts a simple bracket frame that has supports that project from a wall column. The bracket supports a chain-fall hoist. Pinned joints are used to avoid bending. The cost of a link can be *approximated* by $\$ = ¢Al_{\gamma}$, where ¢ is the cost of the link per unit weight, *A* is the cross-sectional area of the prismatic link, *l* is the pin-to-pin link length, and γ *is the specific weight. To be sure, this is approximate because no decisions have been made concerning the geometric form of the links or their fittings. By investigating cost now in this approximate way, one can detect whether a particular set of proportions of the bracket (indexed by angle* θ *) is advantageous. Is there a preferable angle* θ? Show that the figure of merit can be expressed as

$$\text{fom} = -\frac{\gamma ¢ W I_2}{S}\left(\frac{1+\cos^2\theta}{\sin\theta\cos\theta}\right)$$

where *W* is the weight of the hoist and load, and *S* is the allowable tensile or compressive stress in the link material (assume *S* = | *F* / *A*] and no column action). What is the desirable angle θ corresponding to least cost?



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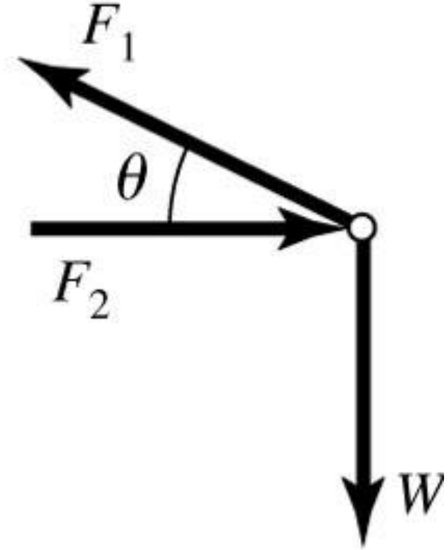

(b)