भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

ME 1050 -Basics of Mechanical Engineering

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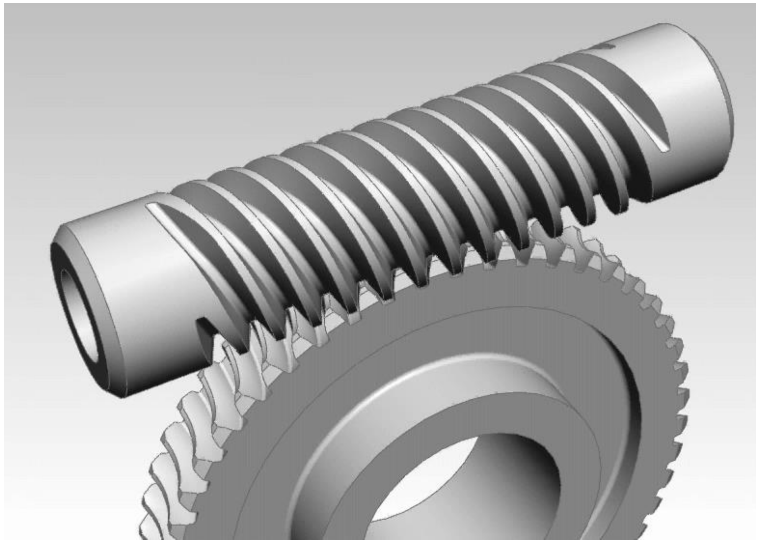
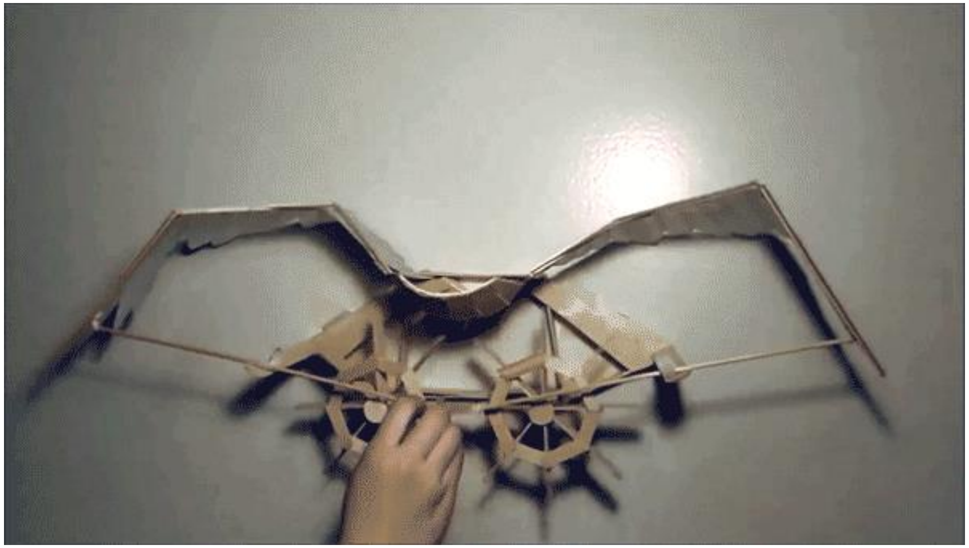
Machine Design

What is Machine Design?

- Creation of new and better machines and improving existing ones, so that it is economical in the cost of production and operation.



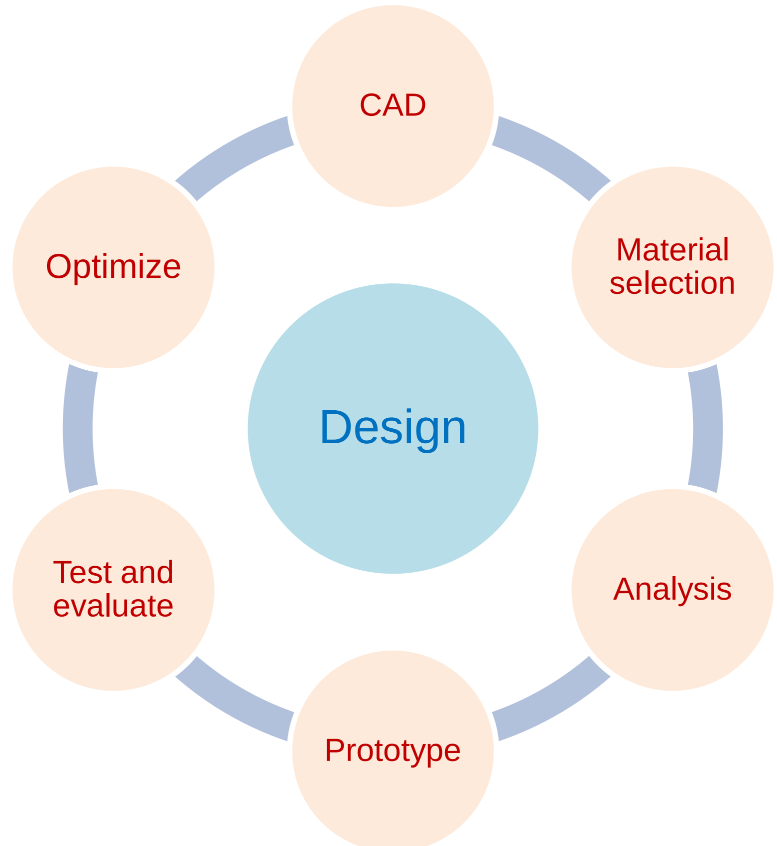
(a)



(b)

Fig. (a) Mechanical Gear (b) Mechanical Flapping
Source: https://gifer.com/en/gifs/mechanical-engineering

Engineering design



Classification of Machine Elements

Machine Elements

- Holding Type Elements
  - Keys
  - Nuts and Bolts
  - Cotters
  - Rivets
- Supporting Type Elements
  - Axles
  - Bearings
  - Brackets
  - Body of Frame
- Power Transmitting Elements
  - Shafts
  - Pulleys and Belts
  - Sprockets and Chains
  - Gears

Basic Requirement of Machine Elements

- Strength and Rigidity
- Wear Resistance
- Minimum Dimensions & Weight
- Manufacturability
- Safety
- Conformance to standards
- Reliability
- Maintainability
- Minimum Life-cycle cost

Engineering Materials and their Properties

- Selection of proper material for the machine components is one of the most important steps in process of machine design.
- The best material is one which will serve the desired purpose at minimum costs.
- Factors Considered while selecting the material: Availability and Mechanical properties.

Mechanical Properties:

- **Toughness:** Ability to absorb energy before fracture takes place.

- **Malleability:** Ability to deform to a greater extent before the sign of crack, when it is subjected to compressive force.

- **Ductility:** Ability to deform to a greater extent before the sign of crack, when subjected to tensile force.

- **Brittleness:** Property of the material which shows negligible plastic deformation fracture takes place.
- Hardness: Resistance to penetration or permanent deformation.

Important Considerations in Machine Design

Types of Load	Stresses caused by the Load

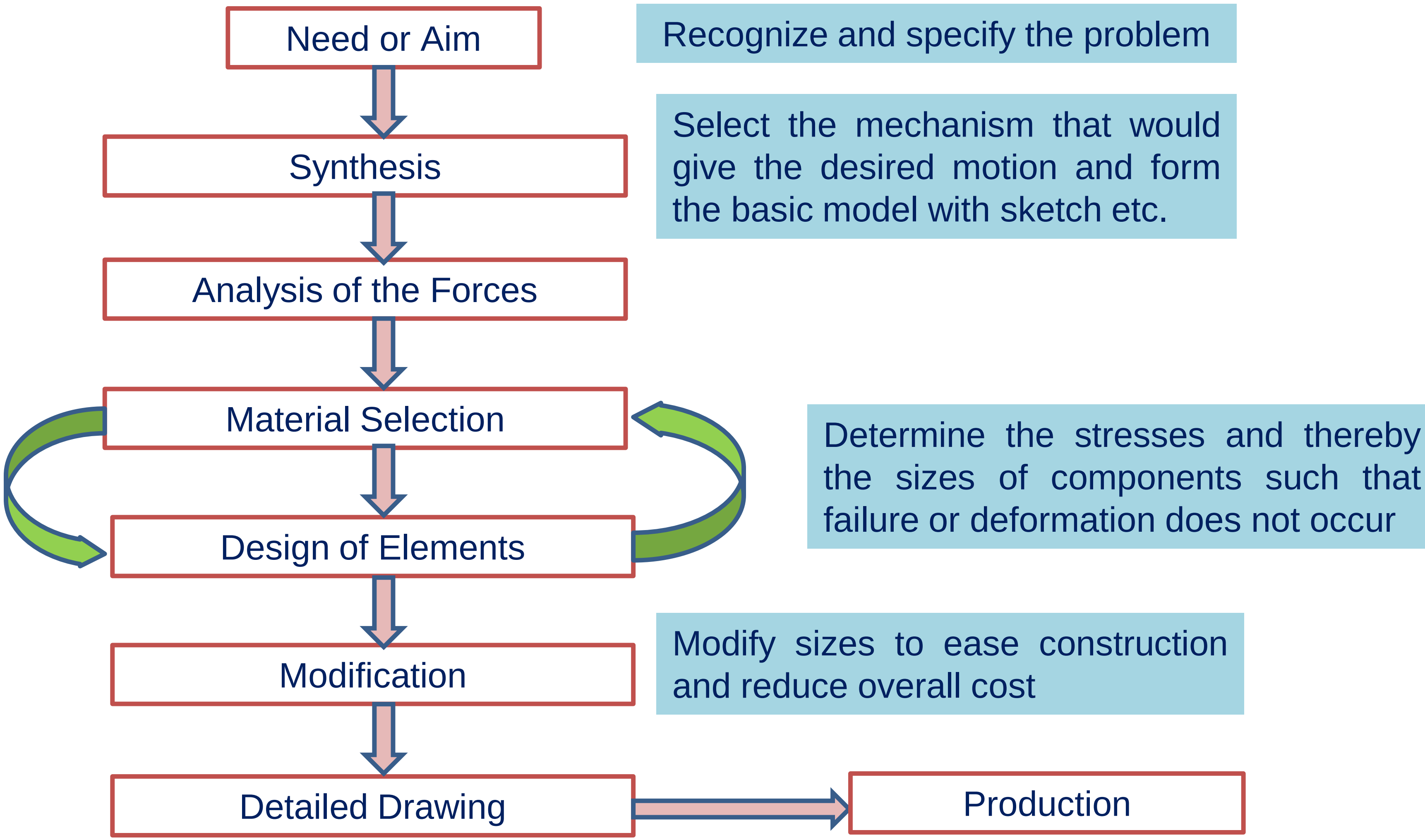
Types of Load

- ➢ Dead Loads
- ➢ Live Loads
  - Steady Loads
  - Variable Loads
- ➢ Shock Loads (Suddenly)
- ➢ Impact Loads (Applied with some velocity)

Stresses caused by the Load

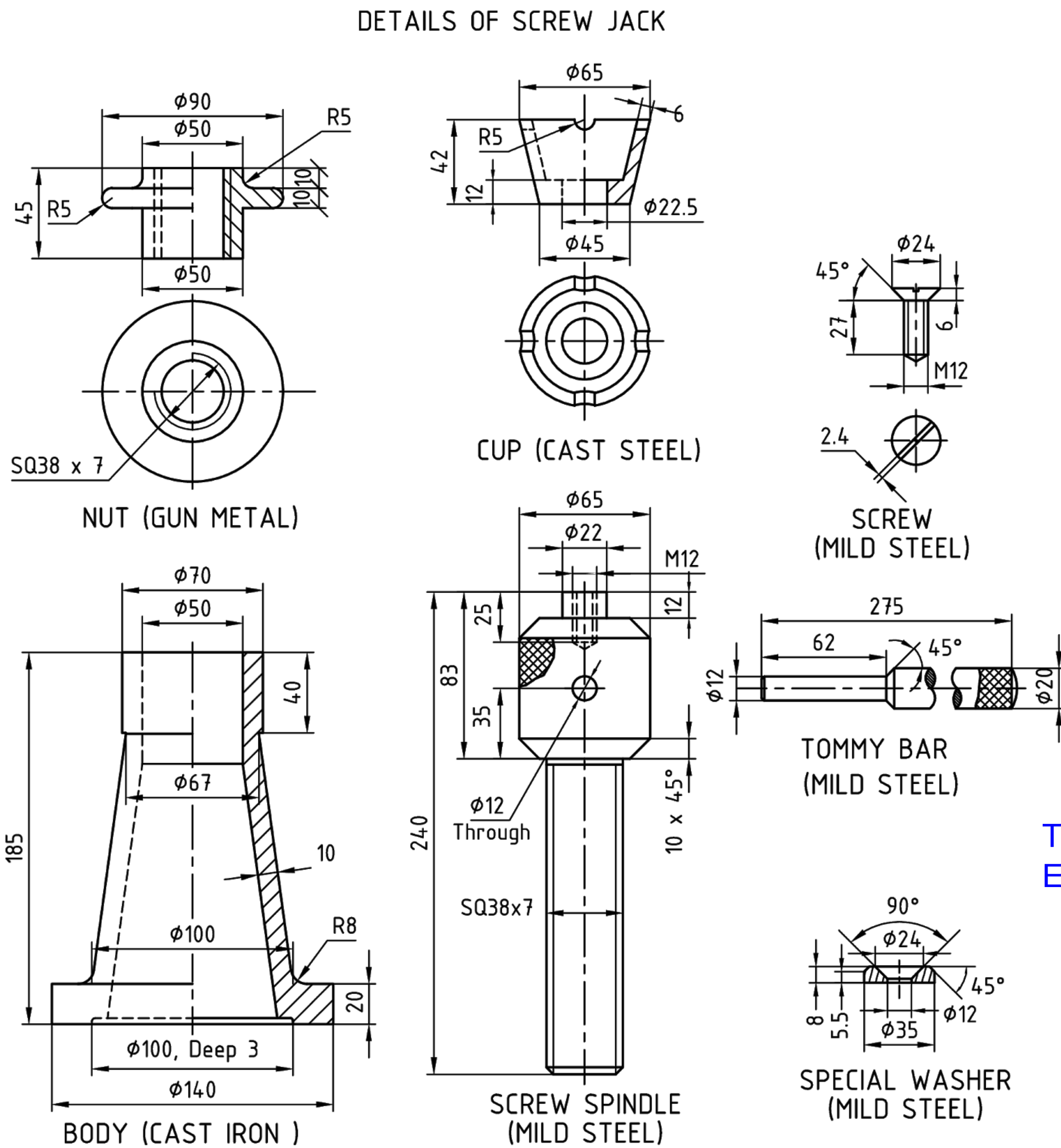
- ➢ Stresses and Strain (Tensile, compressive, shear)
- ➢ Thermal Stresses
- ➢ Torsional Stresses
- ➢ Bending Stresses
- ➢ Combined Stresses

General Procedure in Machine Design



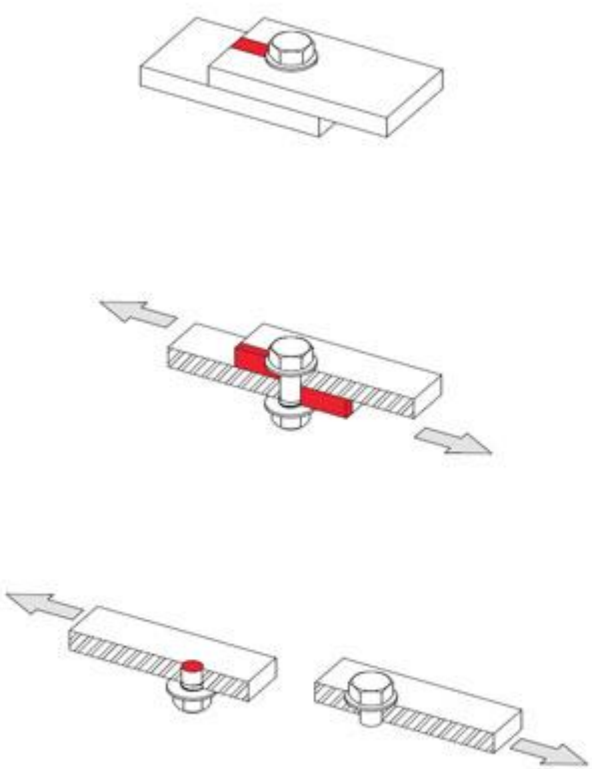
Design Skills Required

- Technical Drawing
- Computer-Aided Engineering (CAE)
- Manufacturing Process
- Statics, Dynamics, and Strengths of Materials
- Lifing
- Kinematics and Mechanisms
- Verbal and Written Communication

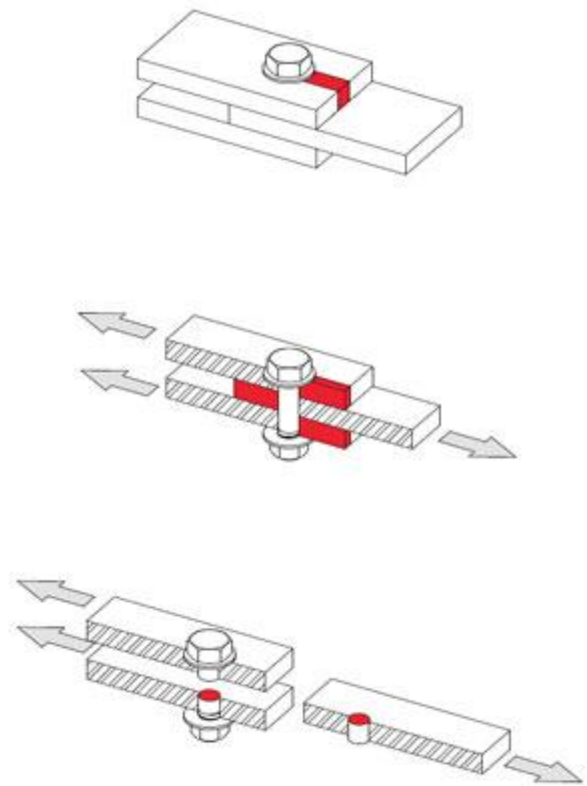


Technical Drawing – Engineers Language

Bolted Joint Connection



Single Lap Joint

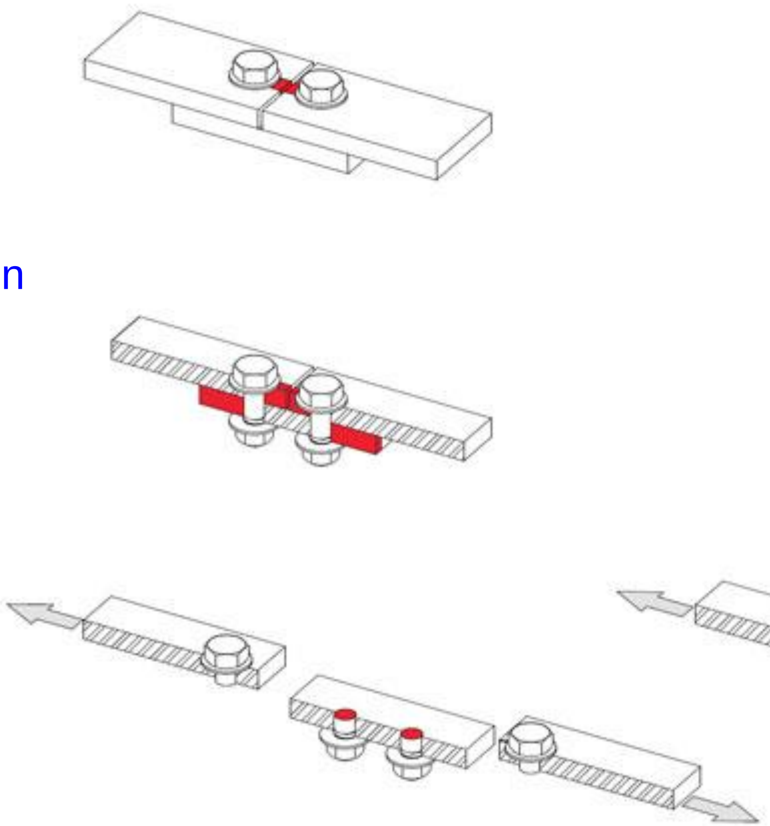


Double Lap Joint

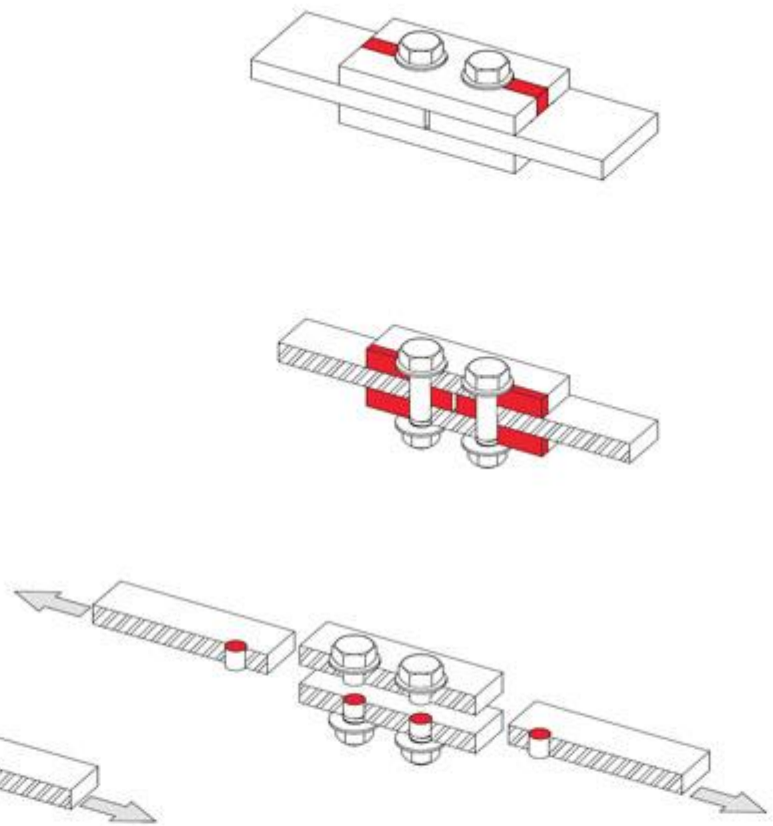
Courtesy: https://www.tboake.com/SSEF1/underconn.shtml

Bolted Joint Connection

Multiple bolted connection



Single Lap Joint



Double Lap Joint

Courtesy: https://www.tboake.com/SSEF1/underconn.shtml

Fatigue and Endurance Limit

- When a material is subjected to repetitive loading, it fails at stresses below the yield point stress. Such type of failure of a material is known as fatigue.
- The failure is caused by means of a progressive crack formation which are usually of fine and of microscopic size. The failure may occur even without any prior indication.

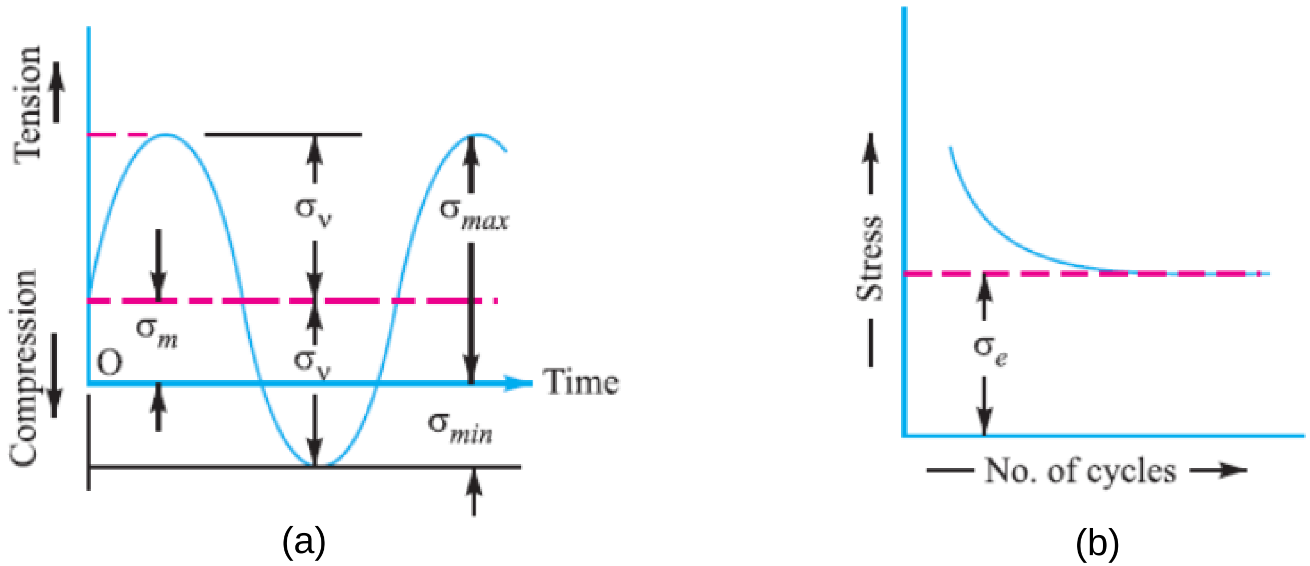


Fig. (a) Fluctuating stress (b) Endurance limit.
Source: https://www.vssut.ac.in/lecture_notes/lecture1529931898.

Goodman and Soderberg Criterion

$$\frac{1}{FOS} = \frac{\sigma_m}{\sigma_u} + \frac{\sigma_v}{\sigma_e} \qquad \text{(Goodman Criterion)}$$

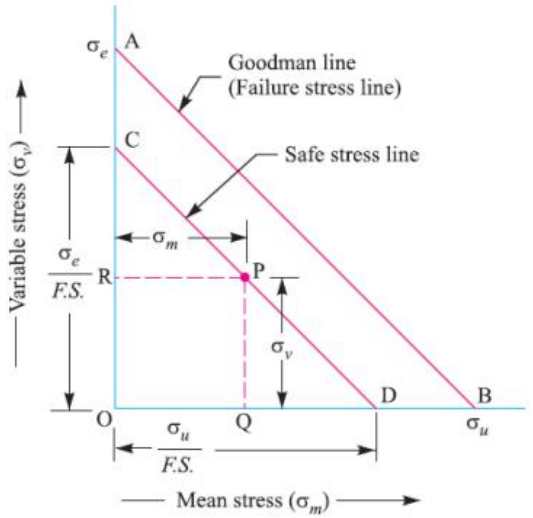
$$\frac{1}{FOS} = \frac{\sigma_m}{\sigma_y} + \frac{\sigma_v}{\sigma_e} \qquad \text{(Soderberg Criterion)}$$

Where, σ_m = Mean stress
σ_u = Ultimate stress
σ_v = Variable stress
σ_e = Endurance limit/fatigue stress

$$\text{Factor of Safety} = \frac{\textit{Endurance limit stress}}{\textit{Design or working stress}}$$

$$\text{FOS} = \frac{\sigma_e}{\sigma_d}$$

(a)



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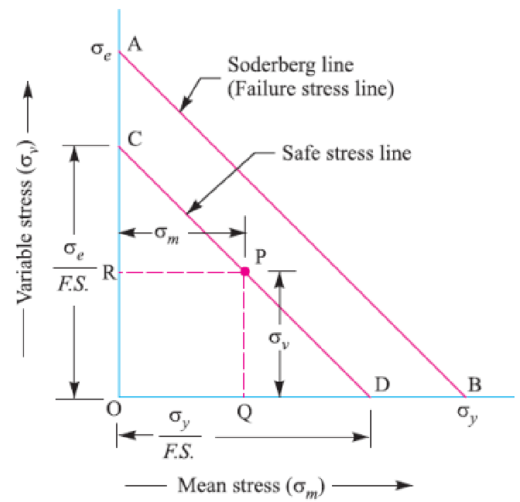


Fig. (a) Goodman method (b) Soderberg method
Source: https://www.vssut.ac.in/lecture_notes/lecture1529931898.

Combined Mean and Variable Stresses

- In practice, this means that fatigue failures are rare when the mean stress is compressive (or negative).

- Therefore, the greater emphasis must be given to the combination of a variable stress and a steady (or mean) tensile stress.

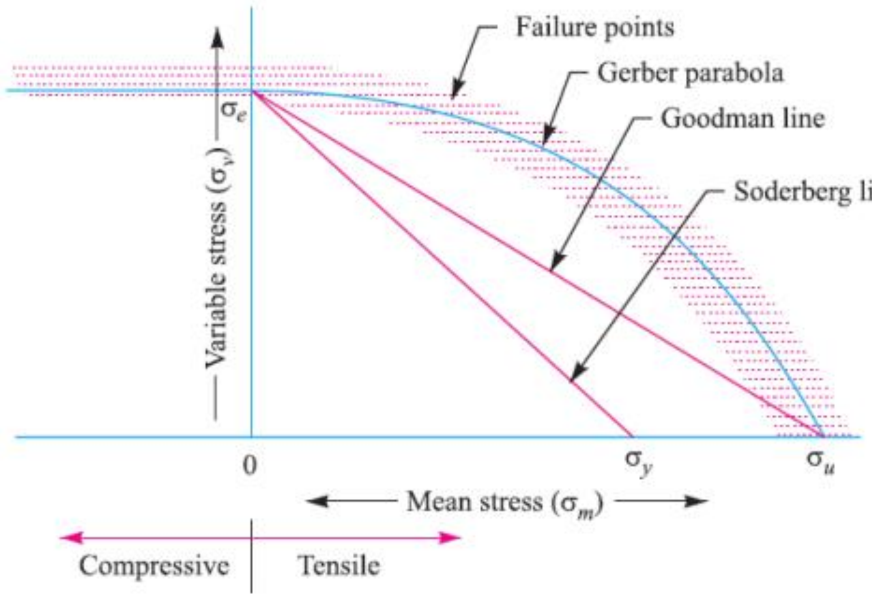


Fig. Combined mean and variable stress

Source: https://www.vssut.ac.in/lecture_notes/lecture1529931898.

Engineering Tolerance

- Engineering tolerance is the permissible variation in measurements derived from the base measurement.
- The failure is caused by means of a progressive crack formation which are usually fine and of microscopic size. The failure may occur even without any prior indication.

Types of tolerances used in measurements:

- Unilateral tolerances
- Bilateral tolerances
- Compound tolerances.

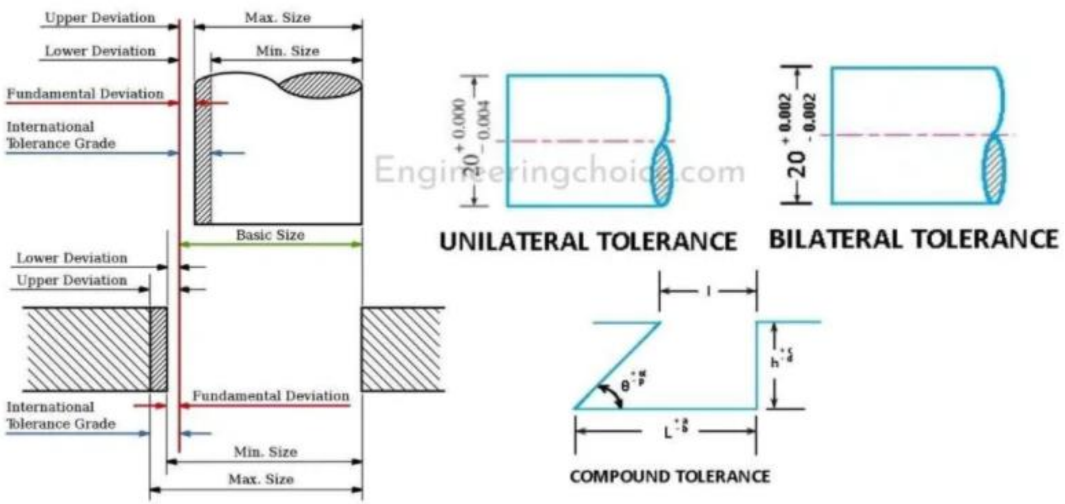


Fig. Engineering Tolerances
Source: https://www.engineeringchoice.com/engineering-tolerance/

Fit and their Types

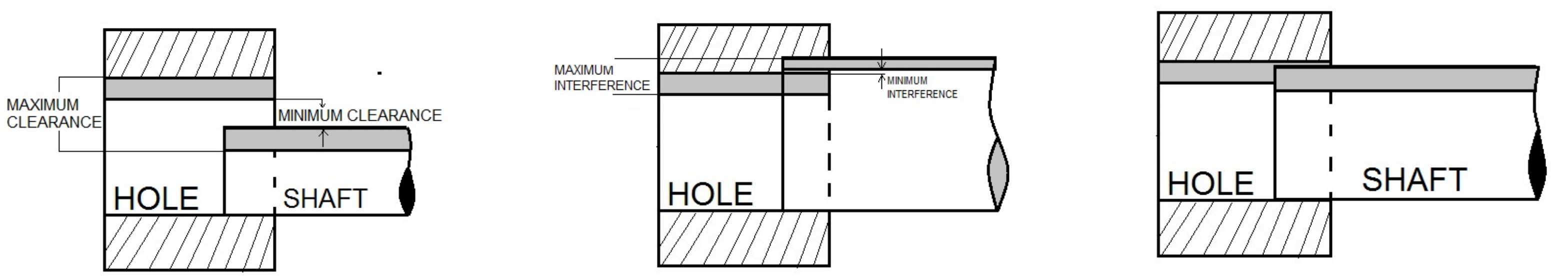
Fit: The degree of tightness or looseness between two mating parts is called a fit.

Types of fits:

- **Clearance Fit**: There is a clearance or looseness in this type of fits. These fits maybe slide fit, easy sliding fit, running fit etc.

- **Interference Fit:** There is an interference or tightness in these type of fits. E.g. shrink fit, heavy drive fit etc.

- **Transition Fit:** In this type of fit, the limits for the mating parts are so selected that either a clearance or interference may occur depending upon the actual size of the mating parts.



(a) (b) (c)

Fig. (a) Clearance Fit (b) Interference Fit (c) Transition Fit.
Source: https://themechanicalengineering.com/types-of-fit/

Design of Springs

Types of spring:

- Helical compression spring
- Belleville spring
- Torsion spring
- Flat spring
- Leaf spring

Pull types springs:

- Helical extension spring
- Torsion spring
- Draw bar spring
- Flat spring
- Constant force spring

Fig. Design of Springs

Source: https://www.iare.ac.in/sites/default/files/DMM-AME012_ME_V%20SEM%20PPT%20corrected_compressed.pdf

Design and Problem Presentation

- Develop a specification set that communicates effectively all manufacturing information, safety information, usage information, etc.

Specifications sets include:

- CAD models
- Drawings (assembly, details, stress reports)
- Bills of material
- Instructions: Manufacturing, assembly, maintenance and usage.

Engineering Method:

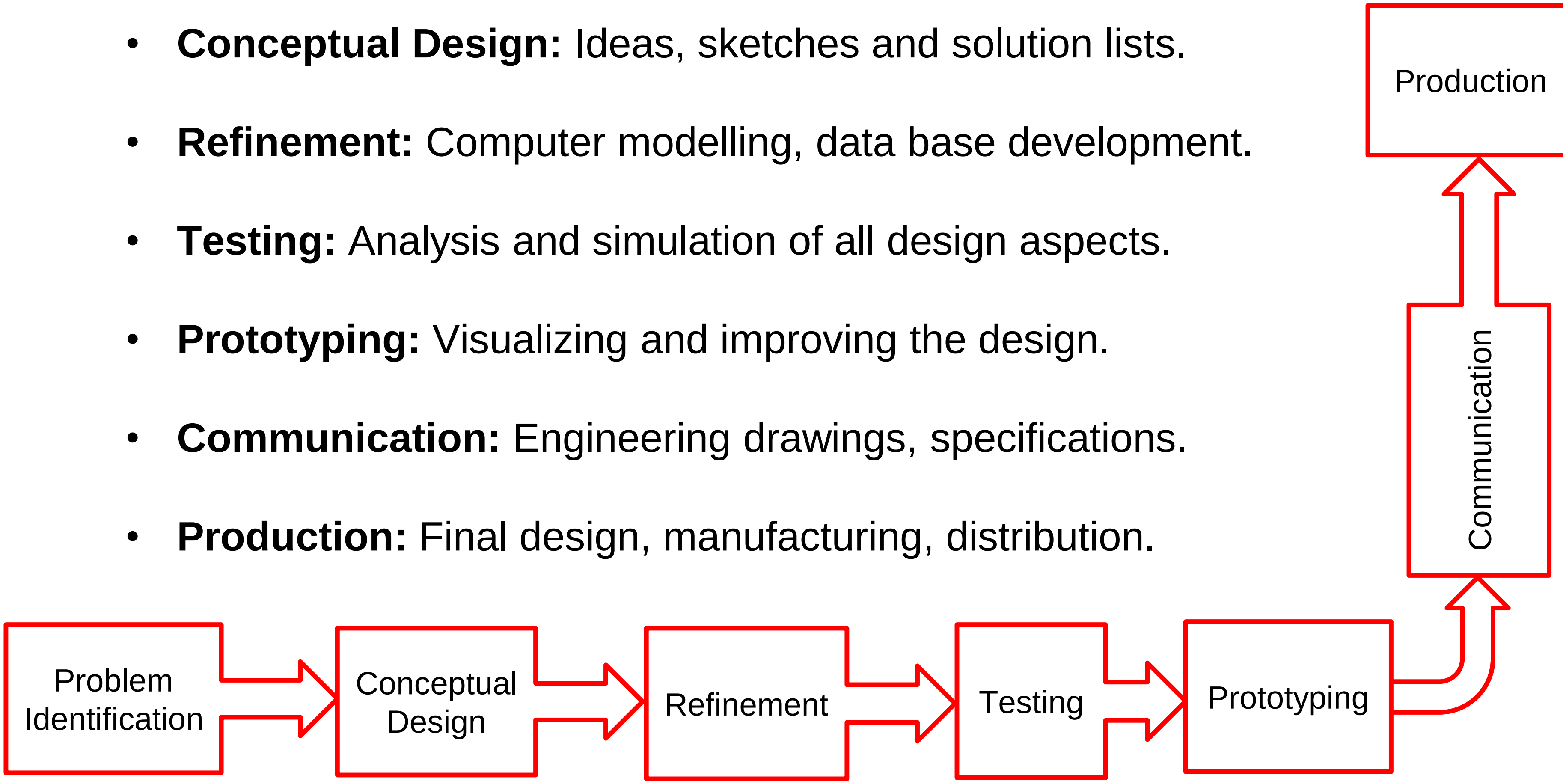
- Recognize and understand the problem
- Accumulate data and verify accuracy
- Select the appropriate theory of principle
- Make necessary assumptions
- Solve the problem
- Verify and check results.

Problem Statement → Diagram → Theory → Solution Steps → Identify Results → Verify Accuracy

Problem Presentation

Engineering Design Process

- **Problem Identification:** Get with customer.
- **Conceptual Design:** Ideas, sketches and solution lists.
- **Refinement:** Computer modelling, data base development.
- **Testing:** Analysis and simulation of all design aspects.
- **Prototyping:** Visualizing and improving the design.
- **Communication:** Engineering drawings, specifications.
- **Production:** Final design, manufacturing, distribution.



Problem Presentation