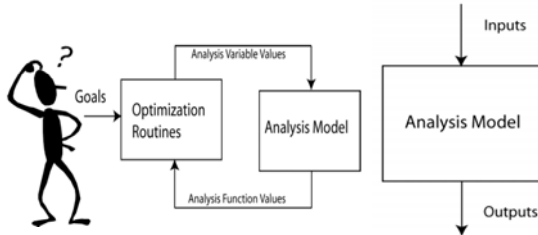


## Lecture 03: Introduction to Engineering Design Optimization



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## Outline

- Introduction
- The Design Process
- Engineering Design vs. Engineering Analysis
- Conventional vs. Optimum Design Process
- Basic Terminology and Notation

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## Introduction

- **Engineering** consists of a number activities:
  - analysis,
  - design,
  - fabrication,
  - sales,
  - research, and
  - development of systems
- **Our focus: The design of systems**
- **Examples of systems:**
  - buildings, bridges, highways, automobiles, airplanes, space vehicles, etc.

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## Introduction

- **Several systems** can usually accomplish the **same task**, and some systems are **better than** others.
- To analyze and design all design possibilities can be time-consuming and costly.
- Usually **one type is selected based on some preliminary analyses** and is designed in detail.
- The design of a system can be formulated as an **optimization problem** → **Design optimization**. (Our focus!)

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## The Design Process

- **Assumptions** must be made to develop realistic models, and the models must be **verified by experiments**.
- Factors to consider during problem formulation:
  - Economic considerations
  - Interdisciplinary environment
- Design is an iterative process → analyzing several trial designs one after another until an acceptable design is obtained.
- In the optimization process, the trial design is analyzed to determine if it is the **best** → cost-effective, efficient, reliable, and durable.

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## The Design Process

System evolution model

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## Engineering Design vs. Engineering Analysis

- The **analysis problem** → determining the behavior of an existing system or a trial system being designed for a given task.
- Determination of the behavior of the system → calculation of its **response to specified inputs**.
- For analysis, **design of the system is known**.
- The **design process** → calculates the sizes and shapes of various parts of the system to meet performance requirements.
- The design of a system is an iterative process → estimates a design and **analyzes it** to see if it performs according to given specifications.

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## Conventional vs. Optimum Design Process

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## Basic Terminology and Notation

- You need to know:
  - Linear algebra (vector and matrix operations) and basic calculus
  - Set and vector notations
  - Notation for Constraints
  - Superscripts/Subscripts and Summation Notation
  - Norm/Length of a Vector
  - Functions
  - Derivatives of Functions

## Norm/Length of a Vector

$$\|x\| = \sqrt{\sum_{i=1}^n x_i^2} = \sqrt{x \cdot x}$$

## Functions

- An assumption: All functions are **continuous** and at least twice **continuously differentiable**.
- A function  $f(x)$  of  $n$  variables is called continuous at a point  $x^*$  if, for any  $\varepsilon > 0$ , there is a  $\delta > 0$  such that

$$|f(x) - f(x^*)| < \varepsilon$$

- Whenever  $\|x - x^*\| < \delta$ .
- Twice-continuous differentiability of a function implies not only that it is differentiable two times, but also that its second derivative is continuous.

## Functions

