GE105
Introduction to Engineering Design
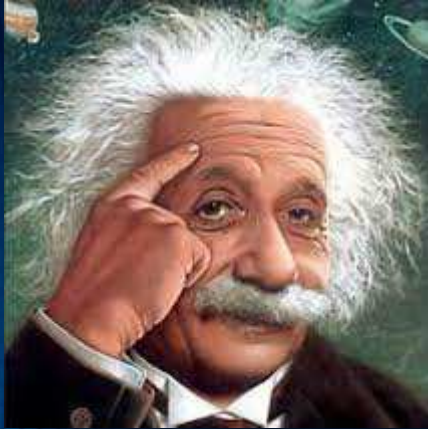College of Engineering
King Saud University

Lecture 5.
Need Analysis and Problem Definition

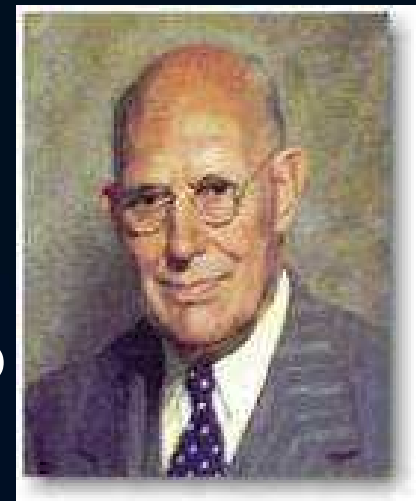FALL 2016
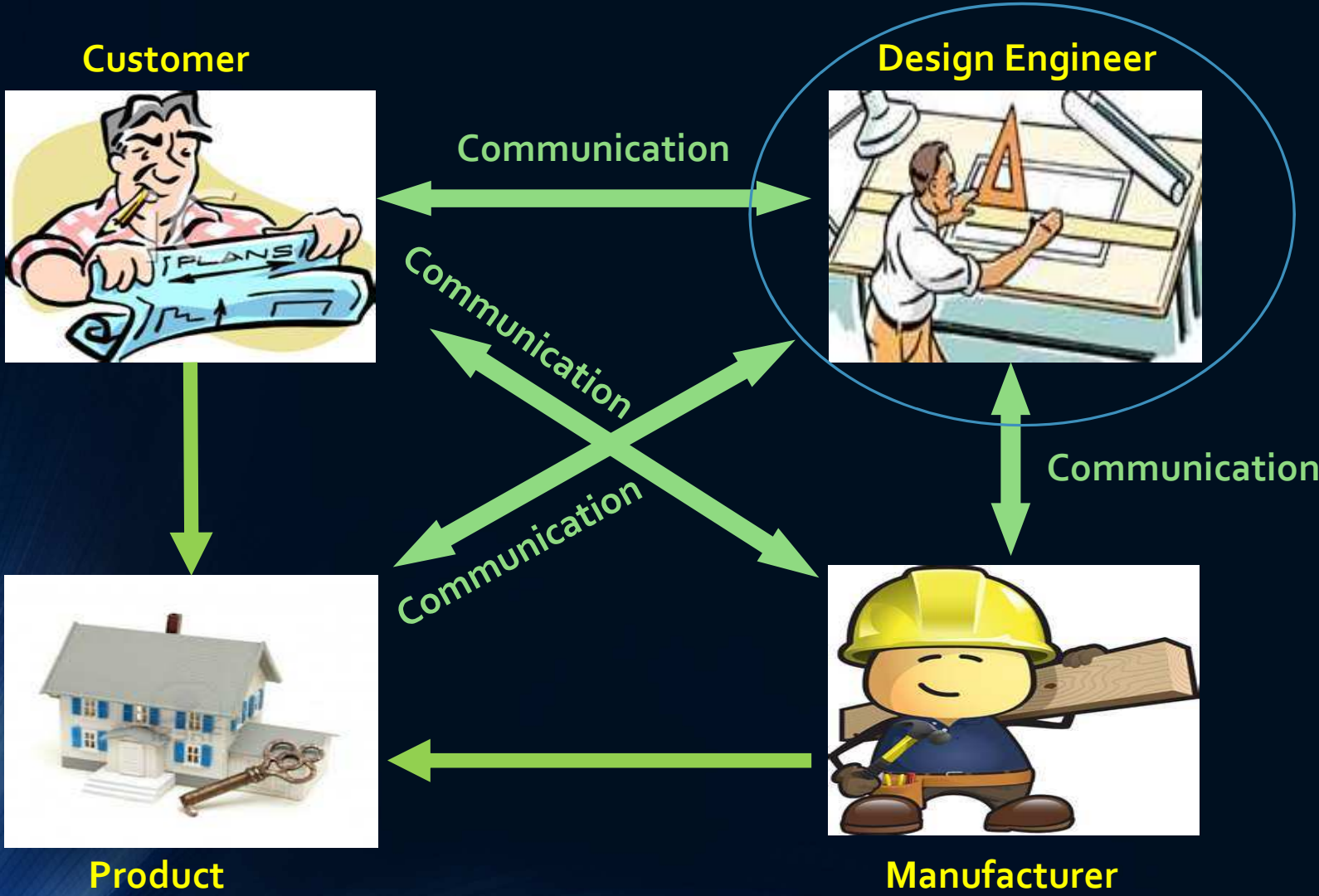
Before We Start

"**If I had only one hour to save the world, I'd spend <u>55 min</u> <u>defining</u> the <u>problem</u> and <u>5 minutes</u> finding a <u>solution</u>**"

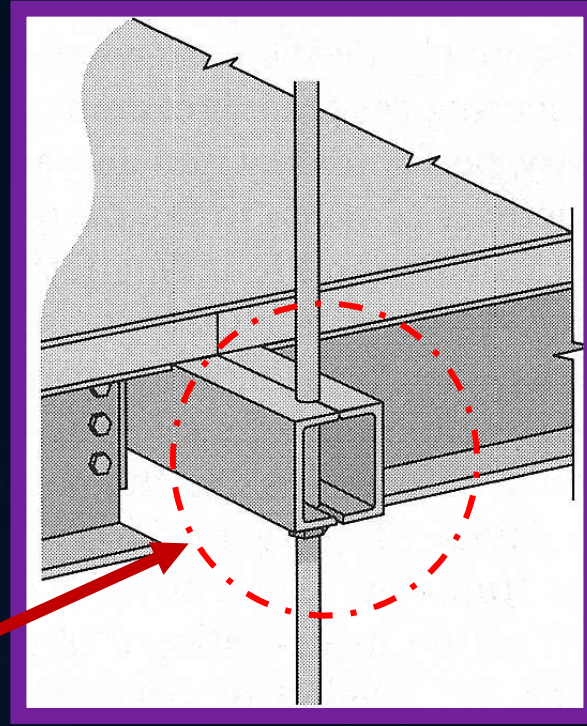"**A <u>problem</u> properly <u>stated</u> is <u>half solved</u>**"
Charles Kettering (American inventor and the holder of over 300 engineering patents)

The Big Picture

Customer

Design Engineer

Communication

Communication

Communication

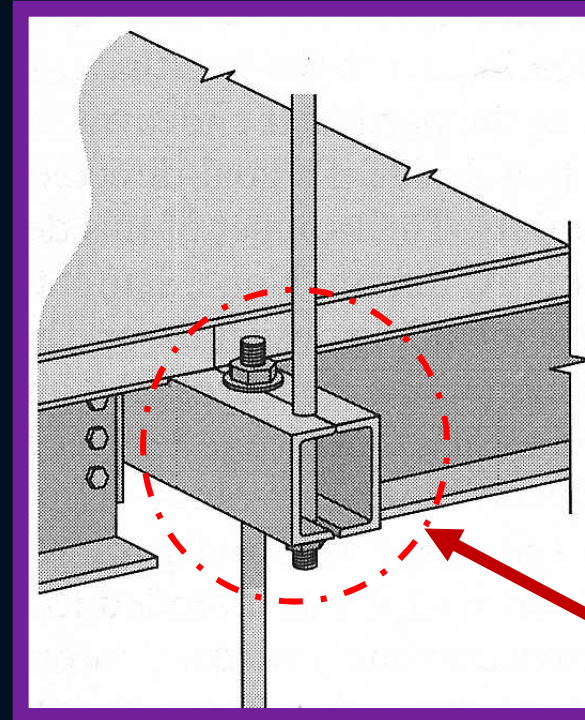Communication

Communication

Product

Manufacturer

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Importance of Communication

Design

Construction
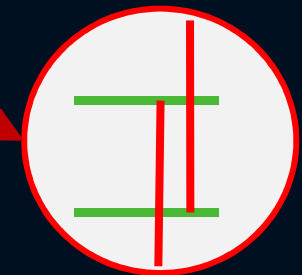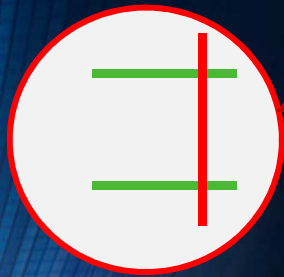
Poor communication between the designer and the construction team lead to the collapse of the second floor
114 people died !!!*

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Design Process

Customer needs a solution ➔ (**Client statement**)

Analyze the Needs ➔ **problem definition** and **formulation**

⭐ This lecture

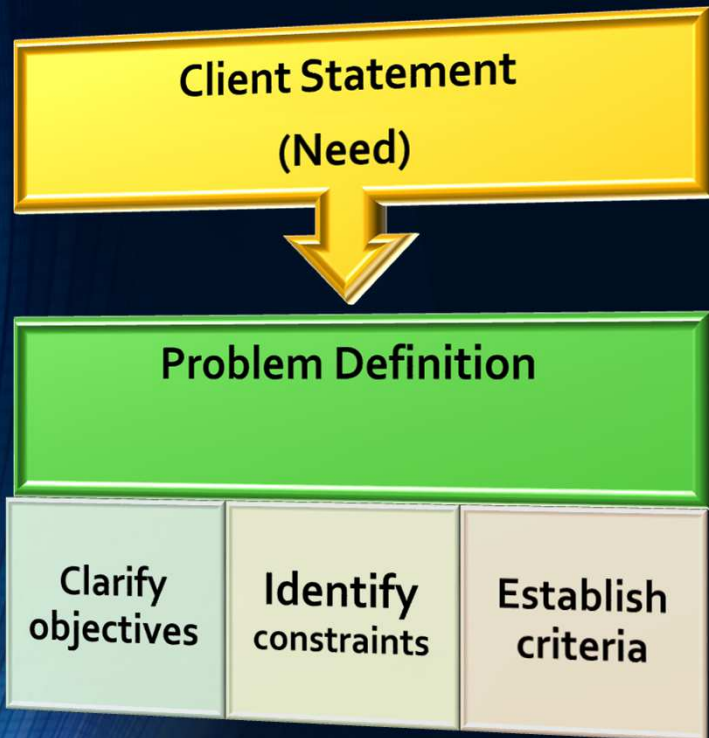**System Design** (Conceptual + Detailed)

System integration and product test

Properly **functioning system**

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Input	Client Need Statement
Tasks	- Talk with the client (interview) - Some potential users (survey) - Brainstorming
Output	- Problem statement - Objectives - Constraints - Criteria

Client's Need Statement

- **First <u>understand</u> what <u>the problem</u> is (what does the customer want?)**
- **Often, the <u>customer does not know exactly</u> what s/he wants nor what is achievable**
- **Client Statements usually have <u>limitations</u> such as:**
  - **<u>Bias</u> (e.g., reconsider admission strategy; whereas the problem could be managing classrooms)**
  - **<u>Implied solutions</u> (e.g., replace the door; whereas another solution can be better*)**
- **<u>Make sure</u> that the <u>correct problem</u> is being addressed**

Example

Client Statement:

The <u>residents</u> of one of my tall buildings are complaining that the <u>elevators are slow</u>

Interpretation 1:

you have to <u>install another elevator</u> at a great expense

Interpretation 2:

Put <u>entertainment</u> on the main floors and provide some coffee*

# Problem statement*

- **The statement is a very <u>short paragraph</u> providing answers to (What? Why? How?)**

- **Written in the <u>language of the customer</u>**

- **Normally <u>straightforward</u>, <u>non-technical</u> and non-quantifiable**

The Wright Brothers Example

- **The problem addressed by the Wright brothers at the turn of the 20th century was:**
  Need a <u>manned machine</u> capable of achieving <u>powered</u> <u>flight</u>
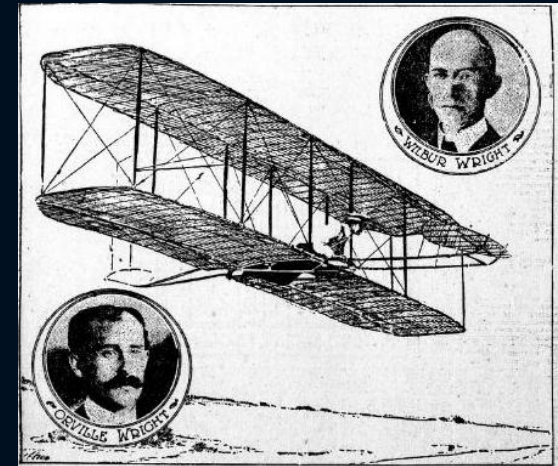
- **This means that:**

  1. They wanted to design a <u>flying</u> machine

  2. It must carry a <u>person</u> (which rules out model aircraft)

  3. An onboard <u>power source</u> must be used to take off (which eliminates hot air balloons)

How to Assess Needs

- **Question the customer**

- **Explore resources (gathering information)**
    - ✓ **Technical literature (books, journals, www)**
    - ✓ **Similar designs (competitors, patent search)**

- **Search legal and regulatory restrictions**
    - ✓ **Allocation of frequency bands**
    - ✓ **Restriction on tower heights**
    - ✓ **Environmental impacts**
    - ✓ **Safety**

- **Brainstorm**

- **Investigate Manufacturability issues**

Types of Specifications

- **Design Specs : provide <u>basis for</u> evaluating the <u>design</u>** (e.g., safe, light, inexpensive, simple)

- **<u>Functional</u> Specs: describe what the product <u>must do</u>** (e.g., drilling, grinding, polishing)

- **<u>Performance</u> Specs: to judge <u>how good</u> is the design** (e.g., speed, energy, accuracy)

✓ **Use (but <u>don't confuse</u>) "<u>D</u>emanded" design elements and "<u>W</u>ished for" design elements**

✓ **Be as <u>specific</u> as possible by using <u>numbers</u> where possible (e.g., not "heavy" but "2.5 kg")**

Common Categories for <u>Specifications</u>

- Performance
- Geometry
- Materials
- Energy
- Time
- Cost

- Manufacturability
- Standards
- Safety
- Transport
- Ergonomics
- Weight

Need Analysis Example Questions*:

1. When and why do you use the product?
2. What do you like about existing products?
3. What don't you like about other products?
4. What are the required functions?
5. Who is the product user?
6. Where is the product going to be used (environment)?
7. What are the unacceptable options/behaviors of the product?
8. What should the product satisfy?
9. What specifications do we have/know?
10. Are there any legal issues?
11. What are the human factors to be considered?
12. What is the expected life duration of the product?

Why?
How?
What?
Who?
Where?
When?

Design Objectives

Objectives are the *requirements* that the **design** is to **satisfy** (**S**pecific, **M**easurable, **A**chievable, **R**ealistic, **T**ime bound)

- **Construct an Objective Tree by:**

  - **Listing** objectives according to the assessed needs

 - **Grouping** the relevant objectives

  - **Forming** a hierarchical tree structure
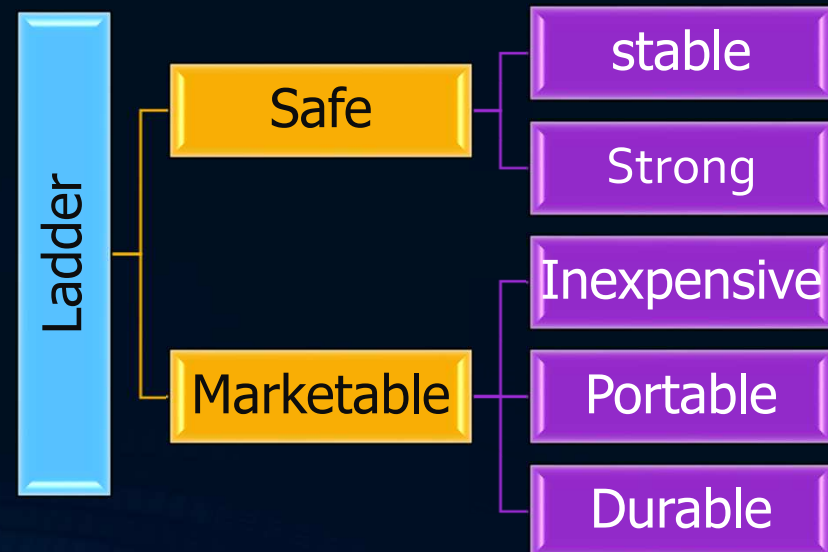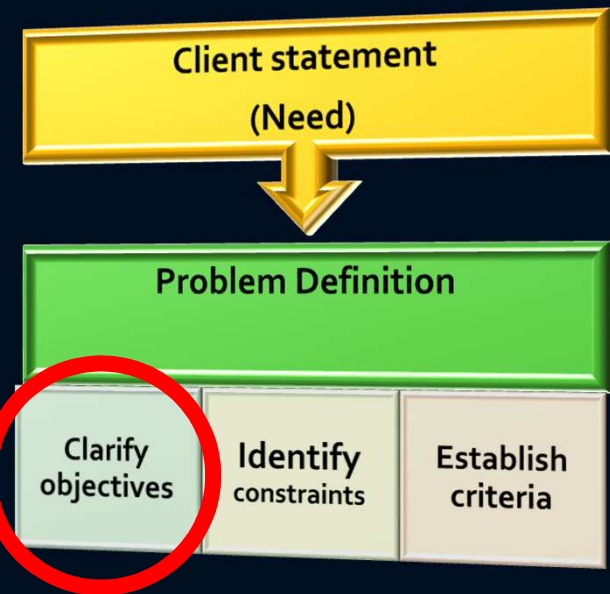
- **The Design Objectives can be <u>divided into</u>:**
  - **<u>Primary</u> (<u>need</u>/must)**
  - **<u>Secondary</u> (wish/<u>want</u>)**
- **The Primary Objective is what the customer/client really needs**
  - **<u>Without</u> the <u>primary</u> objective the <u>design</u> is a <u>failure</u>**
- **The <u>Secondary</u> (less important): objectives are not necessarily specified; but can have an <u>added value</u> to the <u>product</u> (e.g., safety, simplicity, beauty)**

Constraints

- **Constraints are *boundaries* that limit the engineer's flexibility; they form the design envelope (feasible design space)**

- **They help to identify acceptable designs**

- **Should be measurable**

- **Should be answered with: True/False; Yes/No**

  - **Example: Cost <1000 SAR?**
    Weight <500 N?
   **Flexible system (yes/no)?**
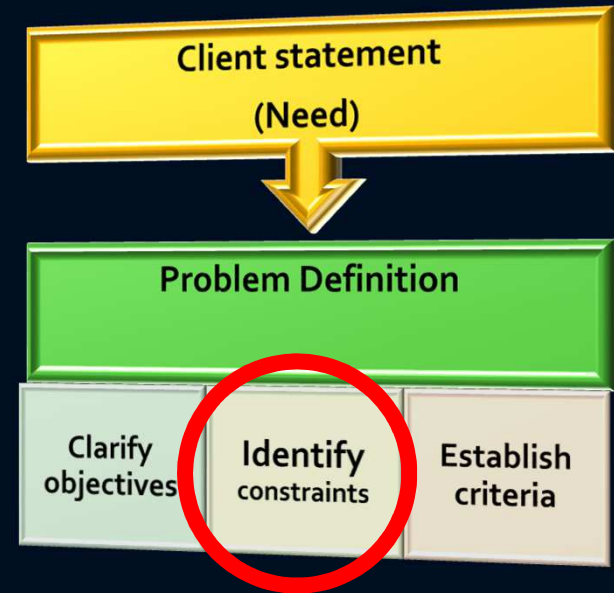
Sources of Constraints

- **Cost**: cost of **design**, **production**, **maintenance**, **support**
- **Time**: **delivery** dates, **processing**, time to market
- **Legal, ethical**: **patent**s, intellectual property, product **reliability**, **safety** requirements
- **Physical**: **size**, **weight**, power, durability
- **Natural factors**: topography, **climate**, resources
- **Company practices**: common **parts**, manufacturing **processes**
- **Human Factors/Ergonomics**
- **Sustainability**
- **Environment**: **bio-degradable** materials, recycled materials, green energy

Design Criteria

- **Criteria are indicators <u>defining</u> the <u>success</u> of achieving the objectives**

- **Criteria define the product <u>physical</u> and <u>functional characteristics</u>**

- **They represent <u>descriptive</u> <u>adjectives</u> that can be qualified on a <u>*given scale*</u>: examples: <u>beautiful</u>, <u>low cost</u>, <u>low noise</u>, smart, <u>low weight</u>**

- **Might be used for <u>judging between</u> <u>different designs</u>**
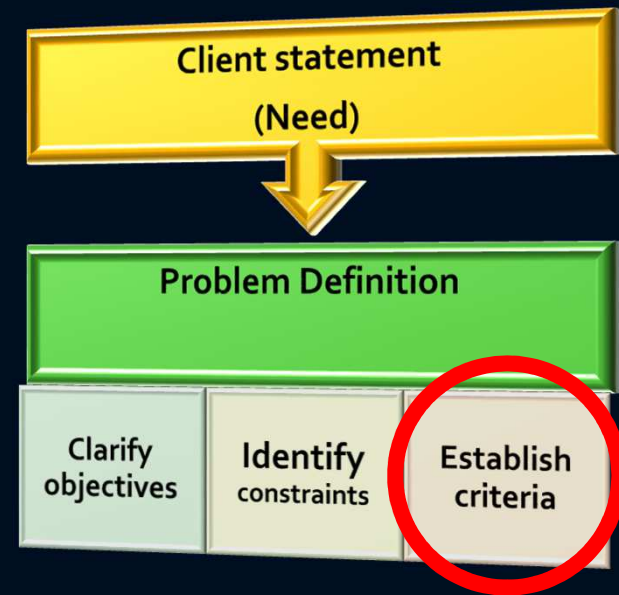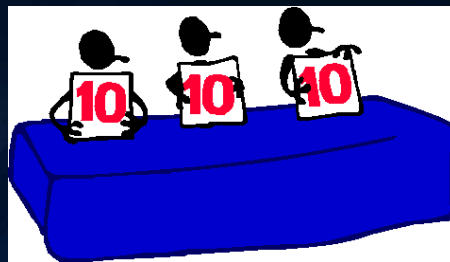
Examples of Criteria

To be qualified say _on a scale 1 to 10_ 1 (worst) and 10 (best) *

- High <u>safety</u>

- <u>Environment</u> friendliness

- <u>Public</u> Acceptance

- <u>Performance</u>

- Ease of <u>operation</u>

- <u>Durability</u>

- <u>Cost</u>

- Ease of <u>Maintenance</u>

- Ease of <u>Manufacturing</u>

- <u>Aesthetic</u> design (Appearance)

- <u>Geometry</u>

- <u>Physical</u> Features

- <u>Reliability</u>

- <u>Use</u> Environment
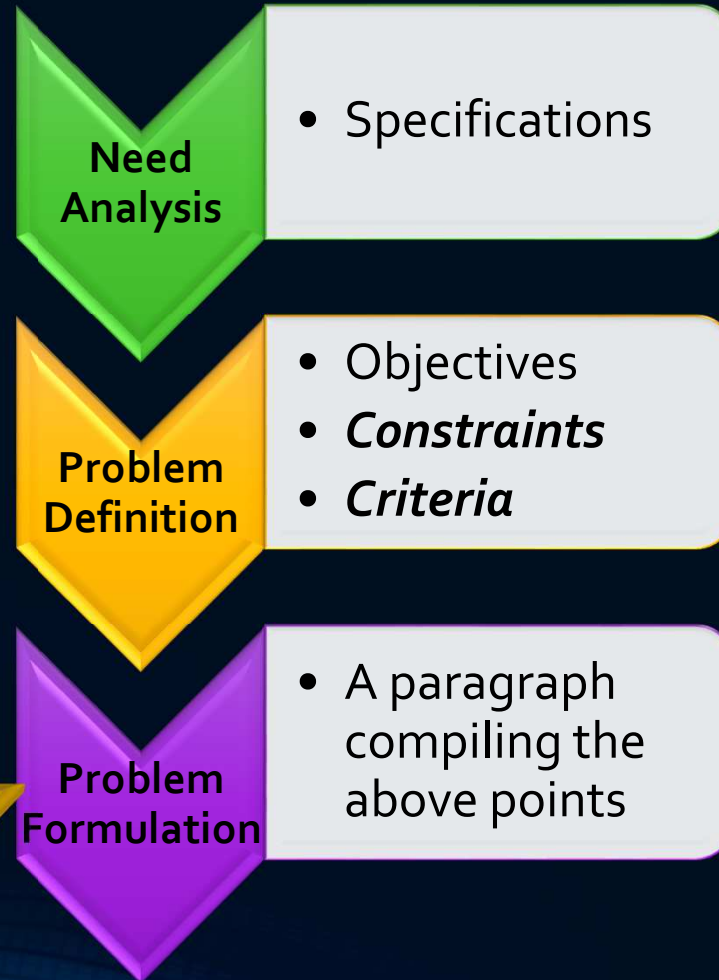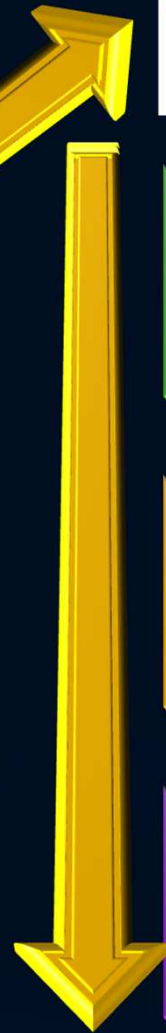
Example: Specs for Designing an "Auto-Golfer"

Geometry	D	Single unit, 3 foot circle
Materials	W	Not degrade in rain and snow, 30°F
Time	D	Ready to go < 14 weeks
Cost	D	≤ $600 (exclusive of radios)
Manufacturing	W	Off-the-shelf parts as possible
Standards	D	Radios OK for FAA regulations
Safety	D	Must pass safety review
Transport	D	Must be portable
Compactness	W	Should fit in a car or small truck

D = demand (i.e. primary obj.)
W = wish (i.e. secondary obj.)

Problem Definition

Why → What → How

Stage	Points
Need Analysis	• Specifications
Problem Definition	• Objectives • *Constraints* • *Criteria*
Problem Formulation	• A paragraph compiling the above points

CLIENTS

To summarize

Need Analysis

- Needs that are well understood
- A well stated objective
- A list of Demanded and Wished for Specifications
- A set of criteria
- A set of constraints

Problem Formulation

- A compiled carefully written paragraph

Problem Definition

- Turn the problem statement into a technical, quantified problem definition
- Precise description of the properties of the object being designed
- Can be a long list

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