EST 200 : DESIGN AND ENGINEERING MODULE I

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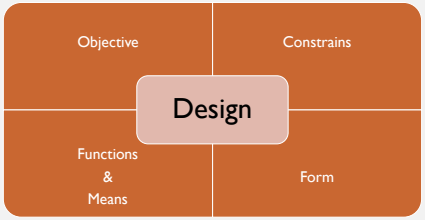
PREAMBLE

- The purpose of this course is to
  1. introduce the undergraduate engineering students the fundamental principles of design engineering,
  2. make them understand the steps involved in the design process and
  3. familiarize them with the basic tools used and approaches in design.

DESIGN ENGINEERING

- Engineering design is a systematic, intelligent process in which engineers generate, evaluate, and specify solutions for devices, systems, or processes whose form(s) and function(s) achieve clients' objectives and users' needs while satisfying a specified set of constraints.
- In other words, engineering design is a thoughtful process for generating plans or schemes for devices, systems, or processes that attain given objectives while adhering to specified constraints.

ASPECTS OF DESIGN



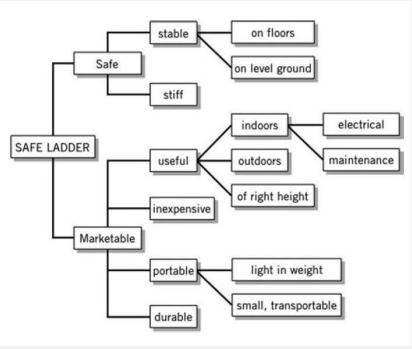
DESIGN OBJECTIVES

- A feature or behavior that we whish the design to have or exhibit
  - It defining the requirements of a design
- Some generic objectives are
  - To identify the need of the user
  - To research about the possibilities of the problem solving
  - To formulate a working principle
  - To reduce the cost
  - To reduce the complexity
  - To make eco-friendly material

EXAMPLE: OBJECTIVE OF A PORTABLE LADDER

- Ladder should be compact and portable
- It should be stable on smooth surfaces
- Should stand safely without a support
- Can be used for house hold requirements
- Should be reasonably stiff and comfortable for users
- Must be safe and durable
- Should be relatively economical
- Should be reduce space requirements while packing by means of detachable parts
- The ladder should be marketable

OBJECTIVE TREE



- Depended
- Interconnected
- Hence can arranged in hierarchy

DESIGN CONSTRAINS

- Functional Constraints
  - Overall geometry
  - Kinematics
  - Energy requirement
  - Materials used
  - Control systems
- Safety constraints
- Quality constraints
- Manufacturing Constraints
- Time constraints
- Economical constraints
- Legal and ethical constraints

DESIGN FUNCTIONS

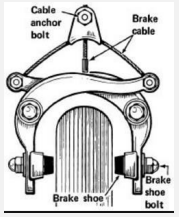
- Functions are the behaviors that expected from the design
- A design should perform certain functions for convert given inputto required output
- They describe what the design (or, more likely, an object within the design) will "do" or accomplish, with an emphasis on input-output transformations
- The statement of a function typically couples an action verb to a noun or object:
  - Eg: lift a book, support a shelf, transmit a current, measure a temperature, or switch on a light

DESIGN FUNCTIONS

- Research function
  - Identifying the need, working principle, collection of data
- Engineering function
  - Main product design, 3D model, concept, simulation, tec.
- Manufacturing function
  - Element production, assembly, cost, purchases, raw materials, etc.
- Quality control function
  - Regulation of product, check for safty, design auditing, energy auditing, etc.
- Commercial function
  - Cost and service related aspects

DESIGN MEANS

- It is the way in which a design executes a desired function
  - Eg: The **function**of a bicycle brake is **stop the wheel**when applying the brake lever by **means**of **frictional force** between rim and brake pad



- Eg: **The function of a speaker is to produce sound by means of electro magnetic induction**

DESIGN FORM

- An area or mass to define objects in space
  - Two dimensional
  - Three dimensional

QUESTION

- Objectives ?
- Constrains?
- Functions?

QUESTION

- Objectives ?
- Constrains?
- Functions?
- Means?

QUESTION

- Objectives ?
- Constrains?
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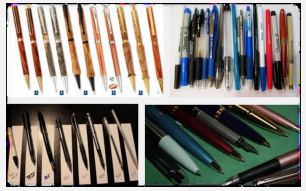
- Means?

SAME FUNCTION DIFF FORMS



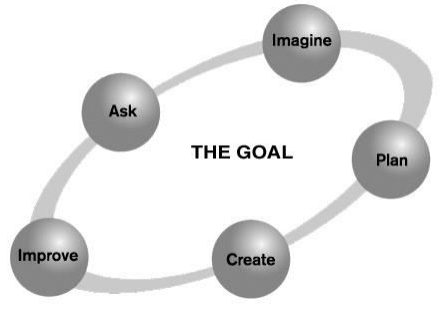
WHAT IS ENGINEERING DESIGN?

- Engineering design is the method that engineers use to identify and solve problems.
- It is a process
- It is purposeful
- It design under constraint.
- It systematic and iterative
- It is a social, collaborative enterprise

WHAT IS ENGINEERING DESIGN?

- The systematic, intelligent generation of specifications for artifacts whose form and function achieve stated objectives and satisfy specified constraints.
- A thoughtful process for generating plans or schemes for devices, systems, or processes that attain given objectives while adhering to specified constraints.
- An activity that intends to produce a description of an artifice in terms of its organization and functioning - its interface between inner and outer environments.

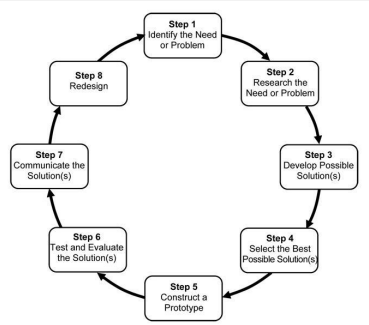
ENGINEERING DESIGN



WHAT IS A DESIGN OBJECTIVE?

- a feature or behavior that we wish the design to have or exhibit.

ENGINEERING DESIGN PROCESS MODELS

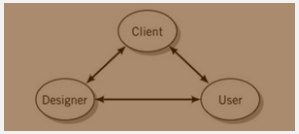


WHERE MIGHT ENGINEERS WORK?

- for a large company that processes and distributes various food products could be asked to design a container for a new juice product
- for a design-and-construction company, designing part of a highway bridge embedded in a larger transportation project
- for an automobile company that is developing new instrumentation clusters for its cars
- for a school system that wants to design specialized facilities to better serve students with orthopedic disabilities

WHAT "ROLES" ARE PLAYED AS THE DESIGN UNFOLDS?

- Client:
  - a person or group or company that wants a design conceived
- User:
  - who will employ or operate whatever is being designed.
- Designer:
  - whose job is to solve the client's problem in a way that meets the user's needs.



ROLES

- Who is the Client?
  - The Client is a person or group or company that wants a design conceived.
- What is the role of the User?
  - The role of the user is to employ or operate whatever is being designed.
- What is the role of the Designer?
  - Solve the client's problem in a way that meets the user's needs.
  - Understand what both the client and users want and need.
  - Design something that can be built and that satisfies everybody.

WHAT IS THE DESIGNER'S FIRST TASK AND WHY?

- A designer's first task is to question the client to clarify what the client really wants and translate it into a form that is useful to her as an engineer. This is the designer's first task because it is typically the client who motivates and presents the starting point for design.

TO WHOM DOES THE DESIGNER HAVE OBLIGATIONS?

- Designers also have obligations not only to:
  - Clients
  - Users
  - their profession
  - the public
- Obligations to the profession and the public are laid out in codes of ethics of engineering societies.

WHAT IS THE ROLE OF THE CLIENT?

- The role of the client is to speak to the designer on behalf of the **intended users**.

WHAT IS ONE THING THAT BOTH THE DESIGNER AND THE CLIENT MUST UNDERSTAND?

- Both the designer and the client must understand what the users want and what the public demands in a design.

ON WHAT TWO STAGES OF DESIGN DOES THE NATURE OF THE DESIGNER'S WORK PARTLY DEPEND?

- The nature of the work of designers depends, in part, on whether they are doing **conceptual design** and **detailed design.**

WHAT IS **CONCEPTUAL DESIGN**?

- **Conceptual design** is the stage at which basic questions of form and content for a design are established (e.g. the nature of the goals of the designed item).

WHAT IS **DETAILED DESIGN**?

- **Detailed design** is a stage in the design process after conceptual design (and after preliminary or embodiment design), **when specific details particular to the design are resolved**.

IN WHAT KINDS OF ENVIRONMENTS DO ENGINEERING DESIGNERS WORK?

- small and large companies
- start-up ventures
- government
- not-for-profit organizations
- engineering services firms

LEARNING AND DOING ENGINEERING DESIGN

- What causes Engineering Design problems to be so challenging and ill-structured?
  - Their solutions cannot normally be found by applying mathematical formulas or algorithms in a routine or structured way.
  - It is not possible to apply formulas to engineering design problems that are well-bounded or even defined.
  - Design problems are open-ended because they typically have several acceptable solutions.

LEARNING AND DOING ENGINEERING DESIGN

- What makes design problems open-ended?
  - Design problems are **open-ended** because they typically have several acceptable solutions.

LEARNING AND DOING ENGINEERING DESIGN

- How is engineering design typically learned?
  - Teaching someone how to do design is not that simple.
  - There is an element of learning by doing, which we call a studio aspect, in trying to teach any of these activities.

LEARNING AND DOING ENGINEERING DESIGN

- What is the studio aspect of learning engineering design?
  - The **studio** aspect of learning engineering design is the element of learning by doing.

ENGINEERING AND DESIGN VOCABULARY

- **Accuracy** :The quality of being near to the true or desired value
- **Analysis** : Breaking an object or process into smaller parts to examine or evaluate systematically
- **Argument** :A persuasive defense for an explanation or solution based on evidence and reasoning
- **Assessment** : An evaluation of the cost, quality and/or ability of someone or something
- **Causation** :The relationship between cause and effect
- **Claim** :A response made to a question and in the process of answering that question
- **Communicate** :To share information orally, in written form and/or graphically through various forms of media

ENGINEERING AND DESIGN VOCABULARY

- **Constraints** :A limitation or condition that must be satisfied by a design, including materials, cost, size, labor, etc.
- **Control** :A variable that is kept the same across all tests for use as the comparison standard
- **Correlation** :A predictive dependent relationship between variables that may be positive or negative. Changing a variable creates a corresponding change in another but does not imply causation.
- **Criteria** :Attributes of a design that can be measured; a set of standards upon which a decision is based
- **Design** (v.) :To generate or to propose a possible solution; to create, fashion, execute, or construct
- **Diagram** (n.) :A visual representation of data or information

ENGINEERING AND DESIGN VOCABULARY

- **Effectiveness** :A determination of how well a solution meets the criteria
- **Efficiency** :The measurable relationship between a solution and the amount of resources it requires
- **Error** :The difference between a measured value and its true or accepted value; important
- **Evaluate** :To determine significance
- **Evidence** : Data used to support a claim
- **Failure** :The inability of a device, process, or system to perform a required function
- **Function** :A specific task that a system or part of a system performs or is intended to perform

ENGINEERING AND DESIGN VOCABULARY

- **Limit** :The minimum or maximum permissible value
- **Model** :A diagram, replica, mathematical representation, analogy, or computer simulation used to analyze a system for condition flaws, test a solution, visualize or refine a design, and/or communicate design features
- **Observation** :To become aware of an occurrence using the senses
- **Plan** (n.) :A systematic approach to solving a problem
- **Problem** :A situation to be changed; a question raised for inquiry, consideration, or solution
- **Process** :A series of steps that form a pathway to a solution
- **Prototype** :A model that tests design performance
- And more..

THE DESIGN PROCESS AS A PROCESS OF QUESTIONING

- With what questions does the engineering design process begin?
  - Client's needs
  - Client's requirements
  - The design process itself

WHAT IS THE HEART OF MODELS OF THE DESIGN PROCESS?

1. Clarifying objectives
2. Establishing user requirements
3. Identifying constraints
4. Establishing functions
5. Establishing specifications
6. Generating alternatives
7. Modeling and analyzing alternatives
8. Testing and evaluating
9. Refining or optimizing the design
10. Setting fabrication specifications
11. Documenting the design

WHAT IS THE SERIES OF DESIGN TASKS IN ORDER?

1. Establish a client's objectives.
2. Identify the constraints.
3. Establish specifications.
4. Generate design alternatives.
5. Model and analyze.
6. Test and evaluate.
7. Refine and optimize.
8. Document the design process and communicate the completed design.

DIFFERENT STAGES IN A DESIGN PROCESS

- **Analyze the situation**
  - Before beginning the design, sort out what problem you are trying to address.
- **Write a brief problem statement**
  - Write a short statement giving the general outline of the problem to be solved.
- **Research the problem through brain storming**
  - Sometimes a problem can be solved "straight out of your head," but in most cases you will need to gain some new information and knowledge.
- **Write a specification – Problem Description**
  - This detailed description of the problem spells out what the design must achieve and what limitations will affect the final solution.

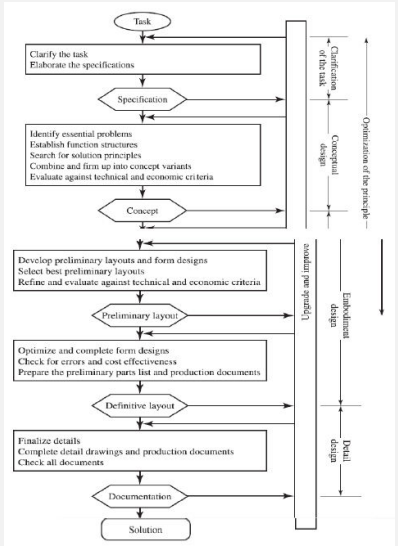
DIFFERENT STAGES IN A DESIGN PROCESS

- **Work out possible solutions**
  - Combine your ideas with information obtained from your research to suggest several possible design solutions. Sketch several possibilities on paper.
- **Select a preferred solution**
  - Decide which solution to develop. Although the chosen solution should, ideally, be the one that best satisfies the specifications, other constraints such as time, cost, or skills may limit the decision.
- **Prepare working drawings and plan ahead**
  - Draw the chosen design including all the details that are important to its construction.
- **Construct a prototype**
  - Make the product. In industry a model is usually built first and the final product is developed from it, but in most classrooms, the model is the final product.

DIFFERENT STAGES IN A DESIGN PROCESS

- **Test and evaluate the design**
  - Testing is ongoing as the construction progresses, but a final test of the entire system or model proves if the project does the job for which it is designed. Look back at the specifications and check the requirements carefully. Ask such questions as: How well does the design function? Does the design look good? Is the product safe to use? Were suitable materials used? How could I have improved on my design?
- **Write a report**
  - The report provides evidence of your work in analysis, planning, designing, carrying out the practical work, evaluating, and communicating.

DIFFERENT STAGES IN A DESIGN PROCESS



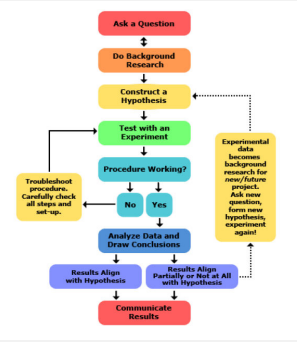
HOW ENGINEERING DESIGN IS DIFFERENT FROM OTHER KINDS OF DESIGN

- **Engineering Design** – Design that applies to engineered structures, infrastructure, technology and machines in creating functional products and processes. It is the creative process of identifying needs and then devising a solution to fill those needs.
- **Interior Design** – Designing interior and exterior environments used by people
- **Landscape Design** – Integration of nature and architecture to create parks and gardens
- **Industrial Design** – Designs products for mass production
- **Fashion Design** – Designing clothes and accessories
- **Software Design** – Outlines the structures, components and methods that solve a problem with software
- **User Interface Design** – Design the interfaces that people use to control and interact with technology
- **Graphic Design** –Visual Designs such as layout of a Magazine

HOW ENGINEERING DESIGN IS DIFFERENT FROM OTHER KINDS OF DESIGN

The Scientific Method	The Engineering Design Process
State your question	Define the problem
Do background research	Do background research
Formulate your hypothesis, identify variables	Specify requirements
Design experiment, establish procedure	Create alternative solutions, choose the best one and develop it
Test your hypothesis by doing an experiment	Build a prototype
Analyze your results and draw conclusions	Test and redesign as necessary
Communicate results	Communicate results

SCIENTIFIC METHOD



ENGINEERING DESIGN PROCESS

DESIGN PROCESS REFERENCES

- https://www.sciencebuddies.org/science-fair-projects/engineering-design-process/engineering-design-process-steps