

Module 1 - 15 % Marks

2 Hours Lecture

Design and its objectives; Design constraints, Design functions, Design means and Design from; Role of Science, Engineering and Technology in design; Engineering as a business proposition; Functional and Strength Designs. Design form, function and strength;

3 Hours Lecture

How to initiate creative designs? Initiating the thinking process for designing a product of daily use. Need identification; Problem Statement; Market survey- customer requirements; Design attributes and objectives; Ideation; Brain storming approaches; arriving at solutions; Closing on to the Design needs.

4 Hours Project

An Exercise in the process of design initiation. A simple problem is to be taken up to examine different solutions- Ceiling fan? Group Presentation and discussion.

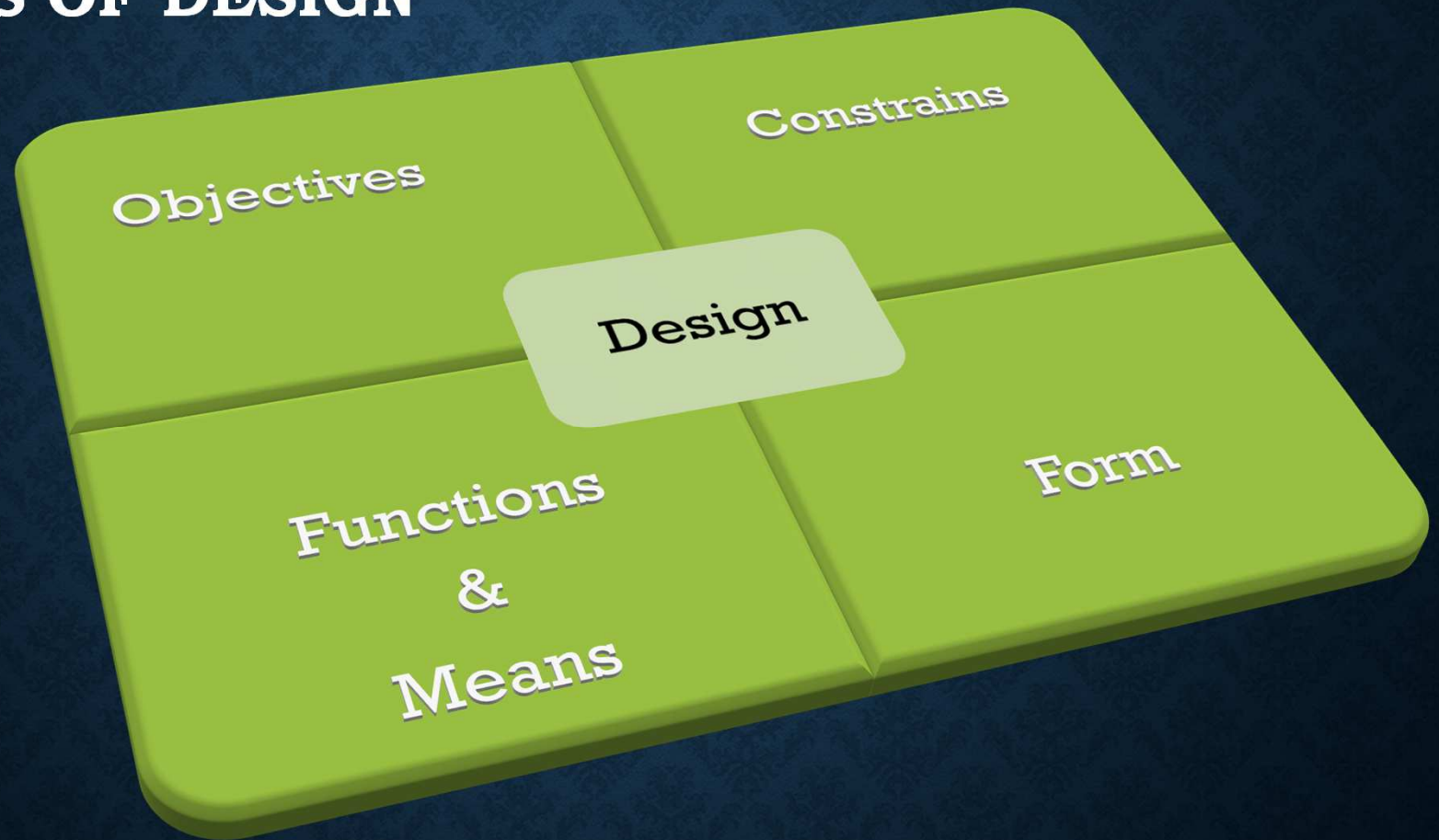
DESIGN ENGINEERING

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.

OR

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



DIVERSITY IN DESIGN

“Transportation facility for long distance”

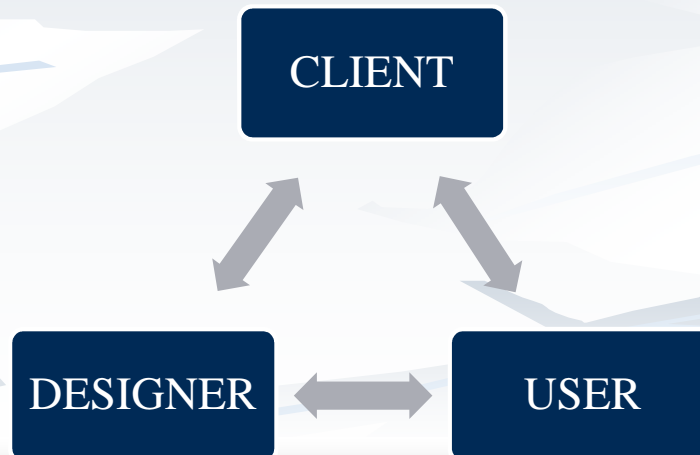


CLIENT, USER & DESIGNER

Client : Person or group or company that wants a design conceived.

User : Who will employ/operate/use whatever is being designed.

Designer : Whose job is to solve the client's problem in a way that meets the user's needs.



TYPES OF DESIGN

1. Adaptive Designing:

- Adapts from existing solution
- No much changes are made to exiting design
- No much training required

2. Development Design:

- Adapts from existing solution
- Results in completely new design
- Requires scientific training & good ability

3. Innovative Design:

- Totally new & innovative concept
- Should have great skill along with imagination



Bifocal Spectacles – Old

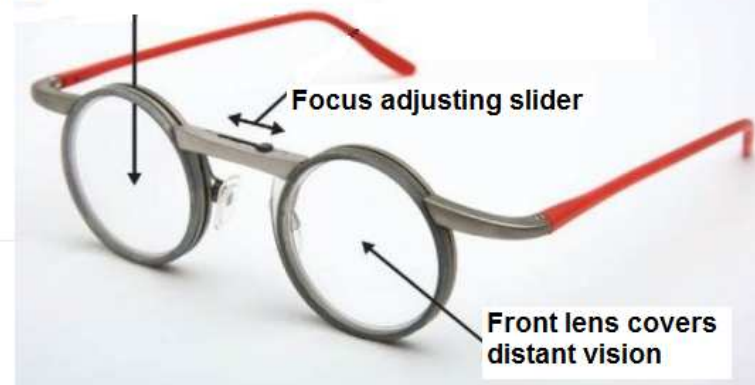


Bifocal Spectacles – Improved



Variable focus Spectacles

Adjustable inner lens holds a fluid that changes the focus as required by pushing the slider



DESIGN OBJECTIVE

A feature or behavior that design should have or exhibit.

- ❖ It is a desired feature/characteristic of a design
- ❖ Determines the effectiveness or suitability for the task.
- ❖ It is not what design should do; It is what the design should be
- ❖ It may be completely or partially achieved.
- ❖ Objectives are normally expressed verbally
- ❖ **Eg: Design a low cost Bicycle**

OBJECTIVES OF DESIGNING 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
- ❖ Useful for electrical and maintenance work

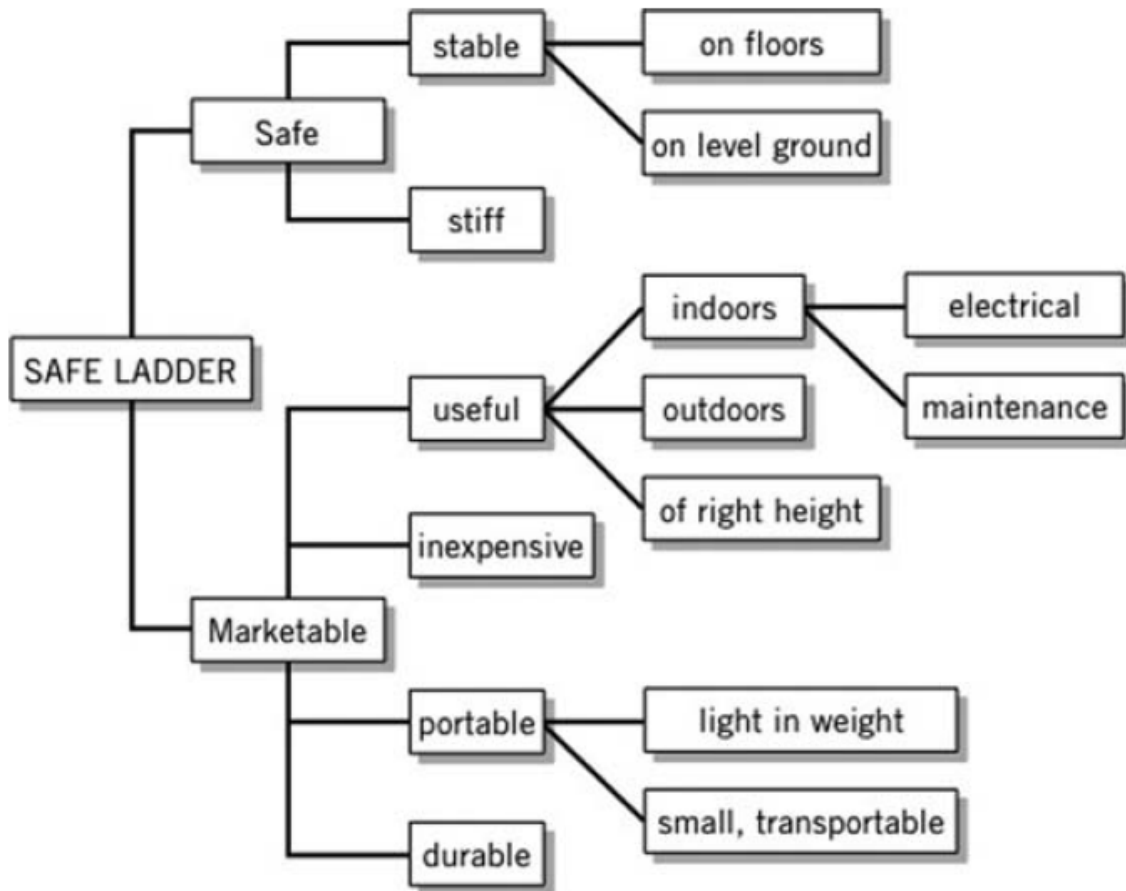


Objectives are normally expressed as adjectives that capture what the design should be, as opposed to what the design should do. For example, saying that a ladder should be portable or lightweight expresses an attribute that the client wants the ladder to have.

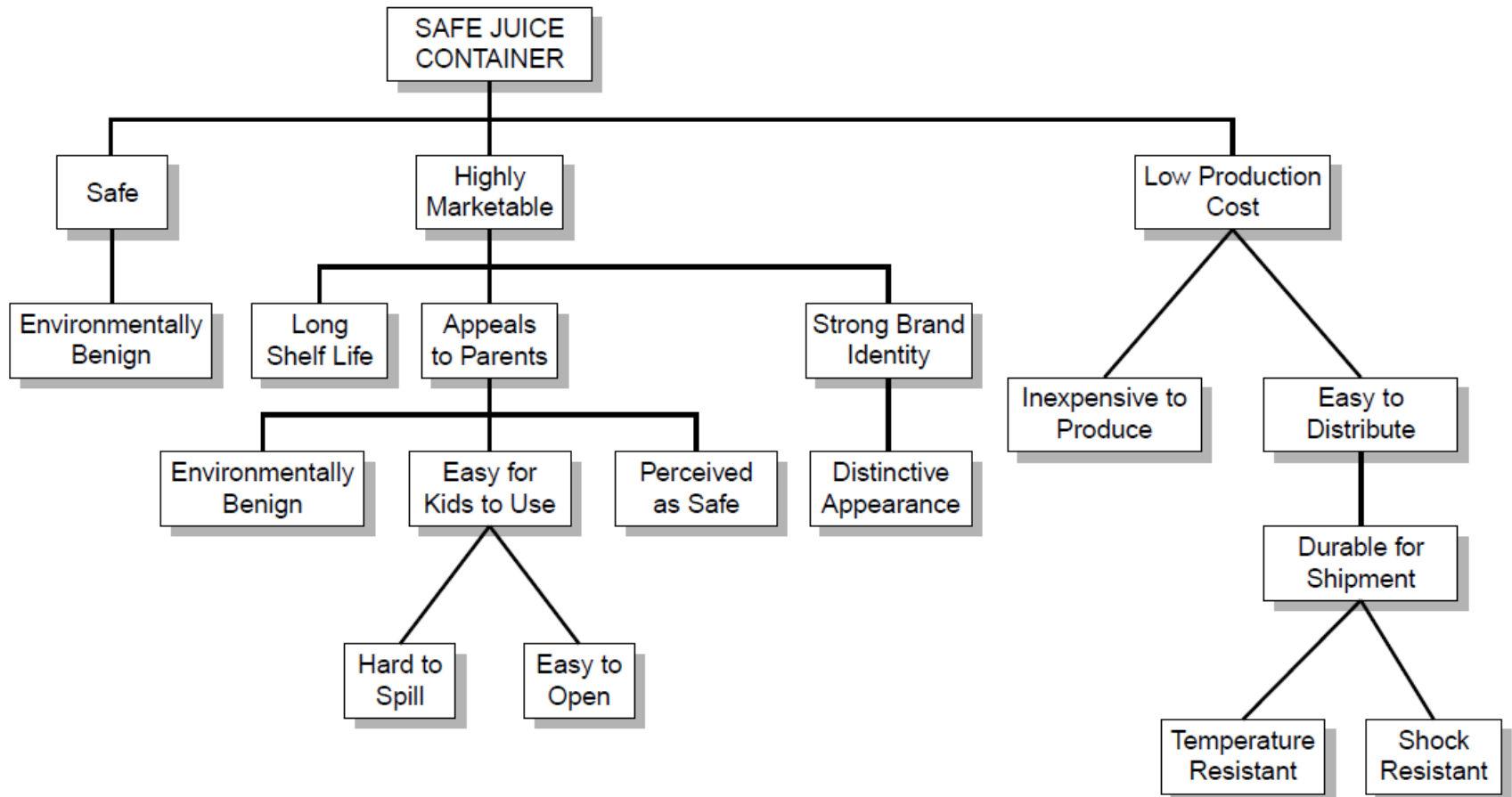
These features and behaviours, expressed in the natural languages of the client and of potential users, make the object “look good” in the eyes of the client or user.



OBJECTIVE TREE



Objectives are depended and interconnected hence it can be arranged in an hierarchy with parent node followed by second stage objectives



Objective tree to design a juice container

DESIGN CONSTRAINTS

a limit or restriction on the features or behaviors of the design.

- ❖ **They are limit on freedom to design.**
- ❖ **They have to be satisfied/ achieved by the design**
- ❖ **Failure to meet the constraint makes design unacceptable**

- ❖ **Eg: Design a bicycle for less than ₹ 2000.**

DESIGN CONSTRAINTS

a limit or restriction on the design's behaviours or attributes

- Constraints are typically framed as a binary yes-or-no choice
- Constraints are important to the design process because they limit the size of a design space by forcing the designer to meet a well defined set of requirements
- Constraints enable us to reject unacceptable alternatives, while objectives enable us to select among design alternatives that are at least acceptable

Characteristic	O	C	F	M
Step deflections should be less than 0.05 in.		✓		
Must meet OSHA requirements		✓		
Must not conduct electricity		✓	✓	

Constraints establish the Design Space



Designed for babies
constrained to support load
up to 15 kg



Designed for adults
constrained to support up
to 150 kg

Develop a accounting software which
executable on Microsoft Windows with
hardware support of 2GB RAM, 32 bit & 1.7
GHz Clock speed

Design a 1-BHK apartment within 50 m²

Design a DC motor which able to runs at
100 rpm along 1kg loading

Design a resistor which offer a resistance
of 100 Ω and capacitor which produce a
capacitance of 50 μf

Constraints are fixed under the consideration of factor of safety (FOS), Standardisation, Customer requirements, Cost, Market etc.

DIFFERENT TYPES OF CONSTRAINTS

Based on the properties affected by constraints

1. *Functional Constraints*
2. *Safety Constraints*
3. *Quality Constraints*
4. *Manufacturing Constraints*
5. *Timing Constraints*
6. *Economic Constraints*
7. *Ergonomic Constraints*
8. *Ecological Constraints*
9. *Life-cycle Constraints*
10. *Aesthetic Constraints*
11. *Legal & Ethical constraints*

OBJECTIVE-CONSTRAIN TREE

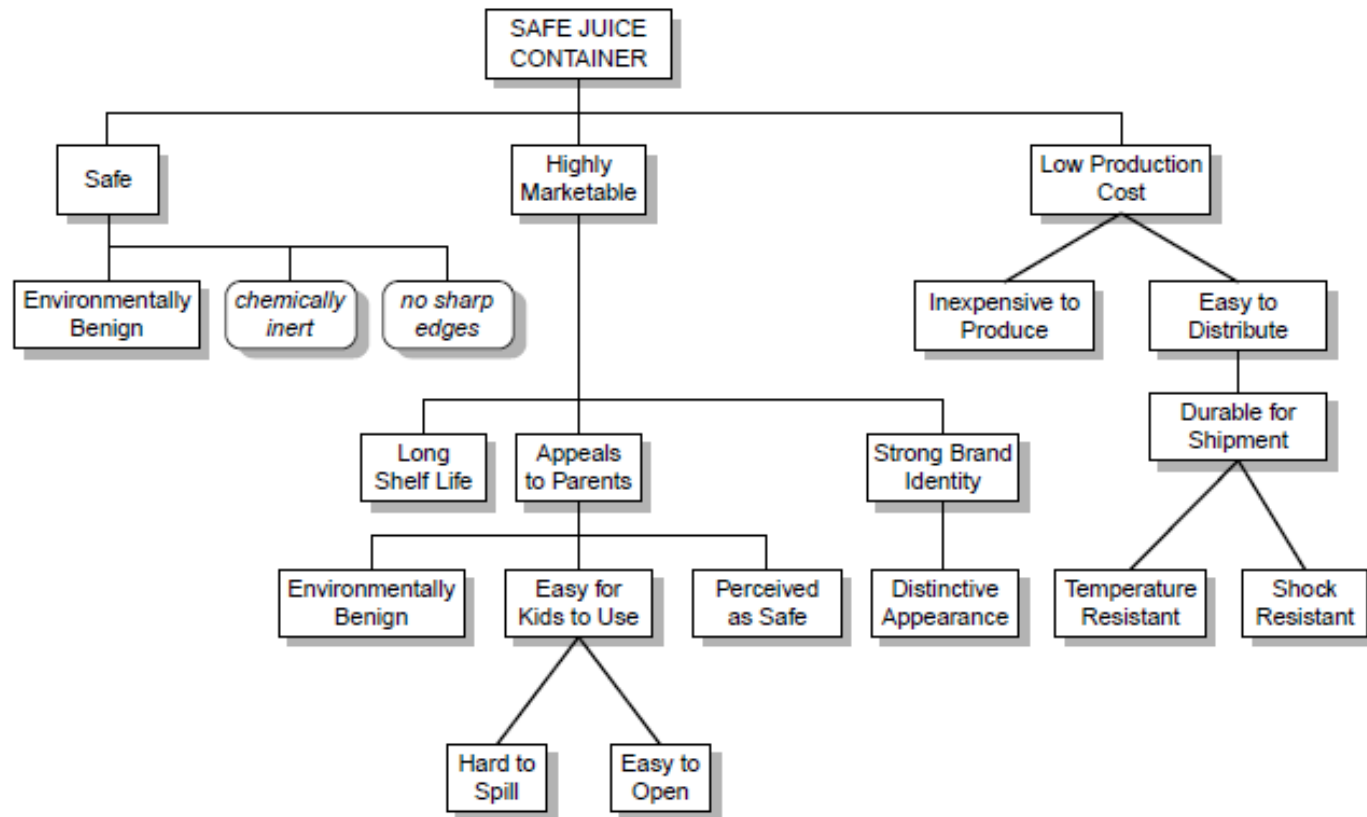


Figure 5.1 A combined objectives (rectangles) and constraints (ovals) tree for the design of a new juice container. Compare this with Figure 4.2 that shows the "standard" objectives tree for the juice container.

OBJECTIVE V/S CONSTRAINTS

Eg: Design a low cost car with indigenous material

Objective: To design a car as cheaply as possible

Constraint: To design with indigenous material

❖ *Cost becomes constraint: To design car for less than ₹ 3,00,000.*

❖ *Material becomes objective in similar fashion*

Objectives are Desirable attributes of a design

Constraints are Required attributes of a design

DESIGN FUNCTIONS

Those things a designed device or system is supposed to do

- Functions are the behaviours that expected from the design
- A design should perform certain functions for convert given **input** to required **output**
- Functions are often expressed as verb-object pairs.
- 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

Things a designed artifact is suppose to do

- ❖ Major characteristic of a design.
- ❖ Establishing design function is of high priority.
- ❖ Generated directly from customer needs.
- ❖ Classified into two
 1. **Basic Function** : *Primary Purpose*
 2. **Secondary Function** : *Support basic function*
 - **Required Secondary Function**
 - **Unwanted Secondary Function**

(CONTD.) DESIGN FUNCTION : AN EXAMPLE

Eg: Design an automobile engine

DesignFunction : *Produce power to drive automobile*

Basic Function : *Produce power*

Required Secondary Function: *Convert energy*

Unwanted Secondary function: *Vibration & Noise*



Measure weight of objects
up to 120 kg



Support weight up to 70 kg
Hold on wall without failure



Control pointer on a computer

Functions

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graph TD; Functions --> Primary[Primary Functions]; Functions --> Secondary[Secondary Functions]; Secondary --> Desirable[Desirable]; Secondary --> Undesirable[Undesirable];
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Primary Functions

Secondary Functions

Desirable

Undesirable



Project Images
(Primary/Basic Function)

Converting Energy
(Secondary function)

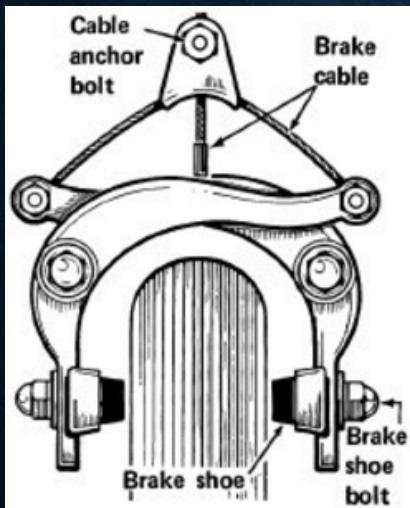
Secondary functions are prerequisites

Generation of Light
(Desirable)

Generation of Heat
(Undesirable)

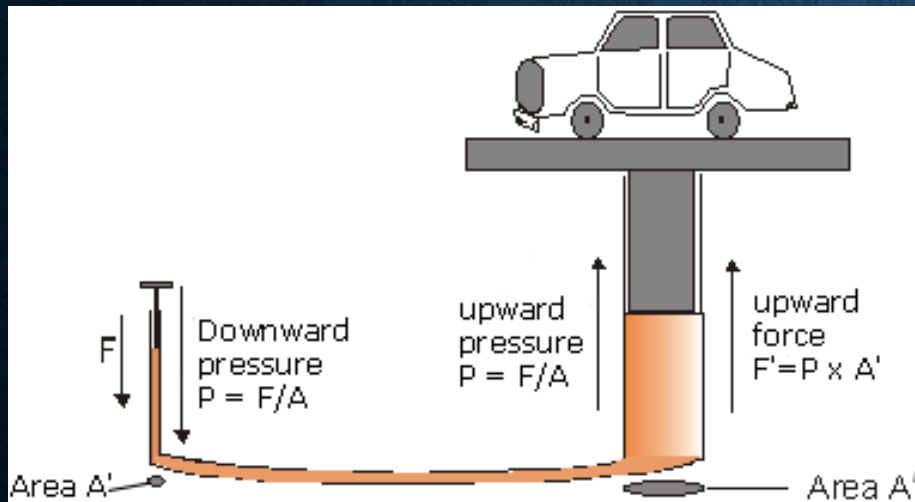
DESIGN MEANS

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



The function of a hydraulic lift is to elevate heavy weight by means of pascals law

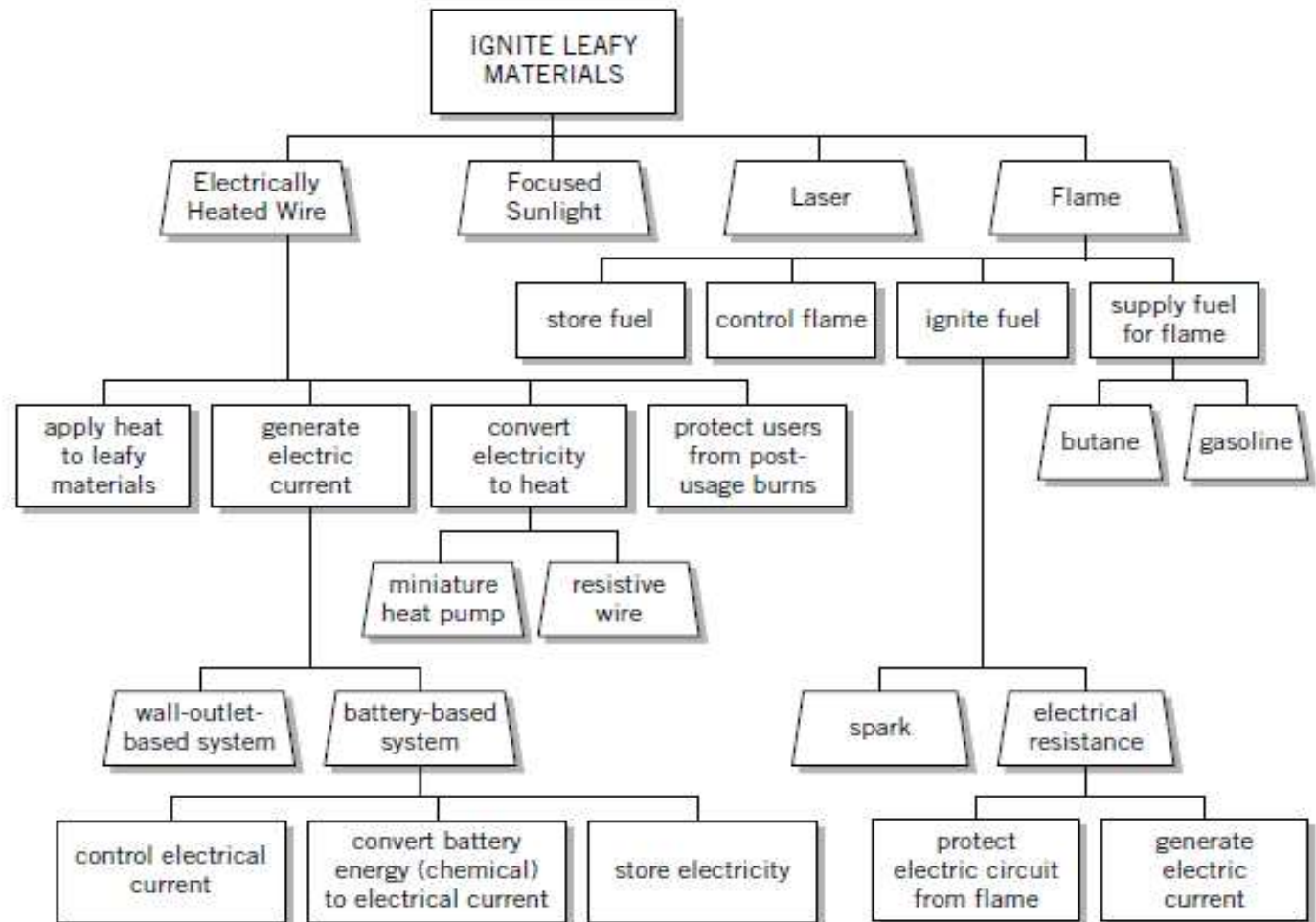


The function of a speaker is to produce sound by means of electro magnetic induction

FUNCTION-MEAN TREE

Design Functions

Design Means



Design aspects of a ladder

Characteristics	O	C	F	M
Ladder should be useful	✓			
Used to string conduit and wire in ceilings	✓			
Used to maintain and repair outlets in high places	✓			
Used to replace light bulbs and fixtures	✓			
Used outdoors on level ground	✓			
Used suspended from something in some cases	✓			
Used indoors on floors or other smooth surfaces	✓			
Could be a stepladder or short extension ladder				✓
A folding ladder might work				✓
A rope ladder would work, but not all the time				✓
Should be reasonably stiff and comfortable for users	✓			
Step deflections must be less than 0.05 in.		✓		
Should allow a male of medium height to work safely up to 11-ft. heights				
Must support weight of an average worker			✓	
Must be safe	✓			
Must meet OSHA requirements		✓		
Must not conduct electricity		✓	✓	
Could be made of wood or fiberglass, but not aluminum				✓
Should be relatively inexpensive	✓			
Should be portable between job sites	✓			
Should be light	✓			
Must be durable	✓			





Objectives ?
Constrains ?
Functions ?
Means ?



Objectives ?
Constrains ?
Functions ?
Means ?



Objectives ?
Constrains ?
Functions ?
Means ?

DESIGN FORM

- Form is the shape of a design
- The design procedure starts from its form
- This has not much to do with the function
- Most of the time Form determines the aesthetics and ergonomics of a product
- For the same function the shape could be different.



Designs with same **Functions** but different **Form**



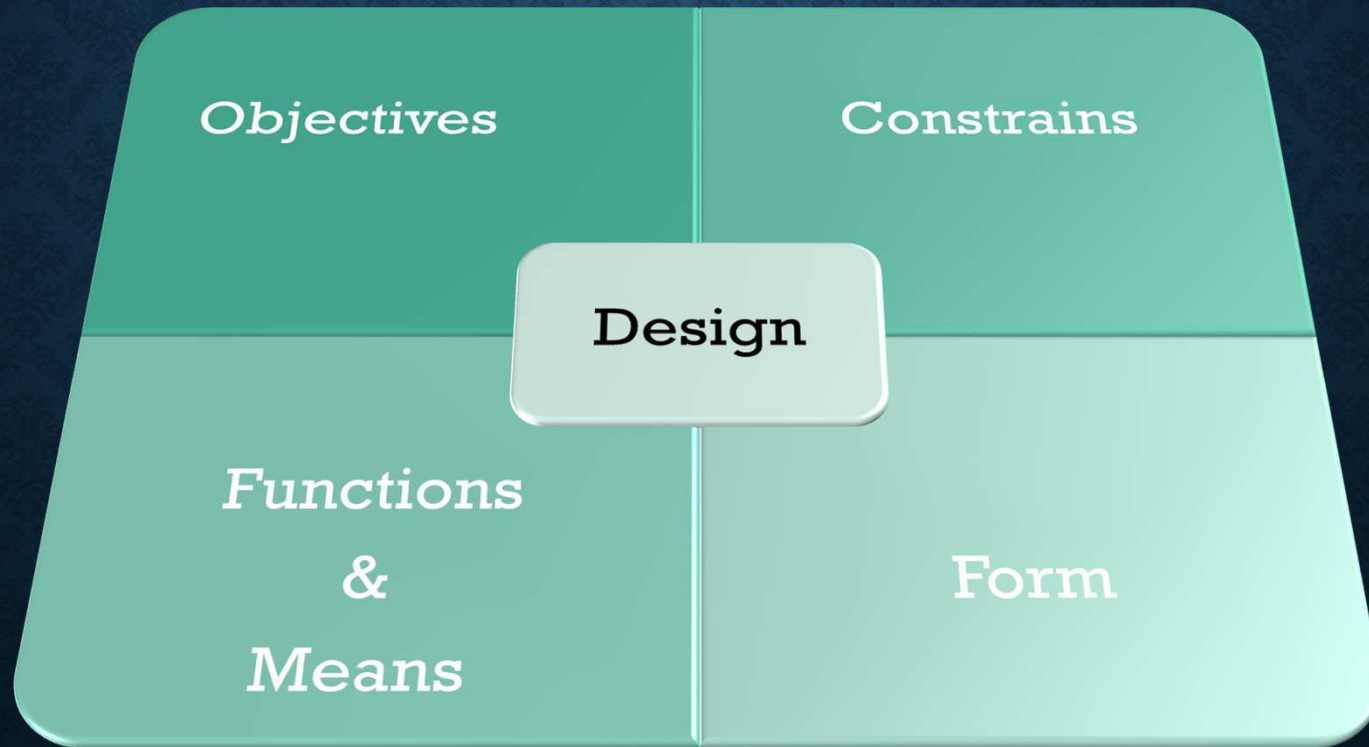
Form determines the Aesthetics



Form determines Ergonomics



ASPECTS OF DESIGN



STRENGTH DESIGN

quality or state of being physically strong

*In strength based designs '**STRENGTH**' has higher priority than any other design considerations.....*



STRENGTH BASED DESIGNS



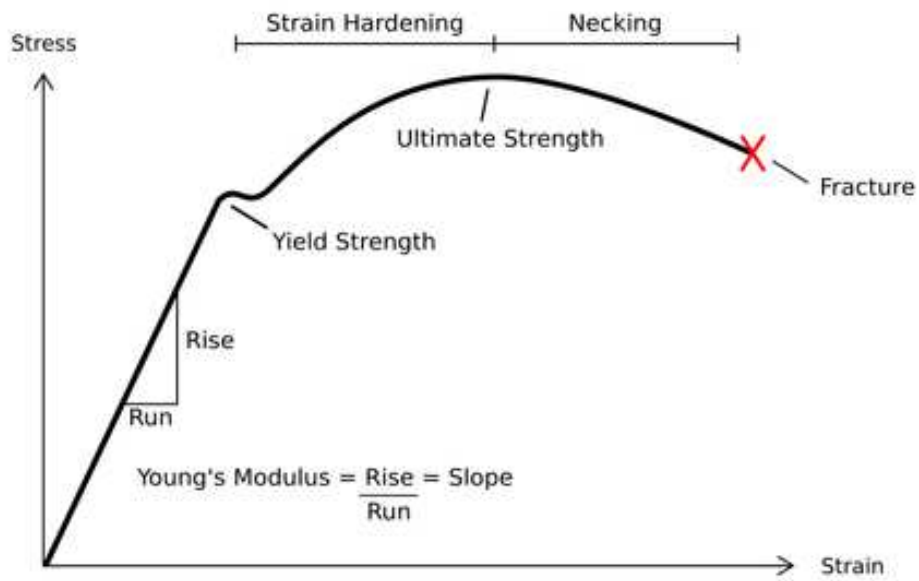
- Strength is the quality or state of being physically strong
- In Design theories strength usually deals with capacity to bear load
- In general strength of a design is the capacity to full fill its functions
- A designed member usually undergoes varieties of loading conditions as per the requirements, hence to sustain these designs the member has to be strong enough
- The importance of strength become crucial in designs which deals with high loading conditions
- In order to prevent failure, the strength of a member has to be greater than the induced stress on that member
- Strength of a design depends up on the material properties, size, geometry, design refinement, design pattern etc.



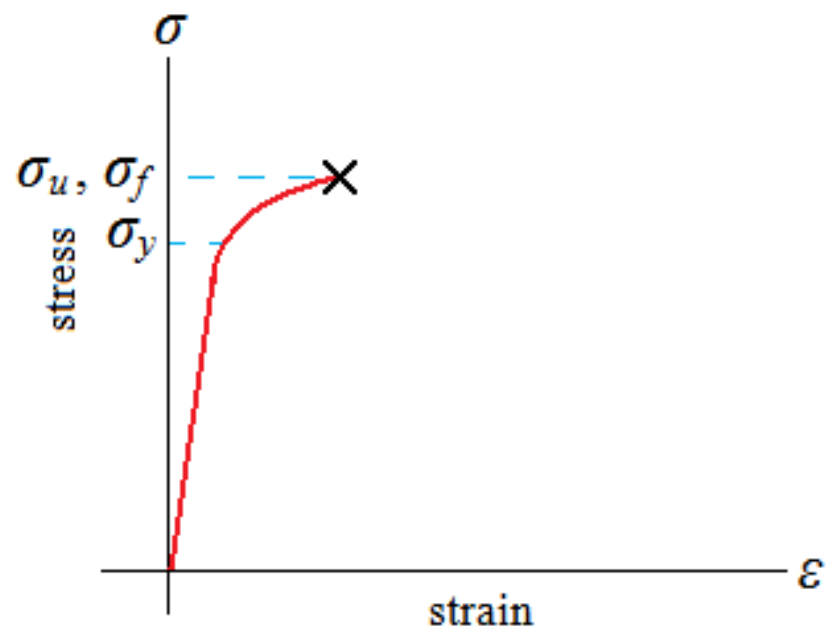
Strength priority designs



Stress & Strain



Ductile Material



Brittle Material

Stress-Strain diagrams used to determine the strength of materials

Factor of Safety (FOS)

Structural capacity of a system beyond the expected loads or actual loads

$$FOS = \frac{\text{Material Strength}}{\text{Design Load}}$$

Design load being the maximum load the part should ever see in service

By this definition, a structure with a **FOS=1** will support only the design load and no more. Any additional load will cause the structure to fail. A structure with a **FOS=2** will fail at twice the design load.

Hence FOS fixed based on the safety requirements

ROLE OF SCIENCE, ENGINEERING & TECHNOLOGY

*Science gives the clue, Engineering Plans
& Technology delivers.*

Sciences give us unique solutions.

Engineering gives us choices.

INTERDEPENDENCY OF SCIENCE, ENGG & TECH : AN EXAMPLE

- Science gives the Principle for temperature measurement -Thermal expansion of solids and liquids
- Engineering uses this principle to design a thermometer
- Technology allows to realize the thermometer.

