



# ENGR 110 / 112 – Design I

## Design Process

### Conceptualization

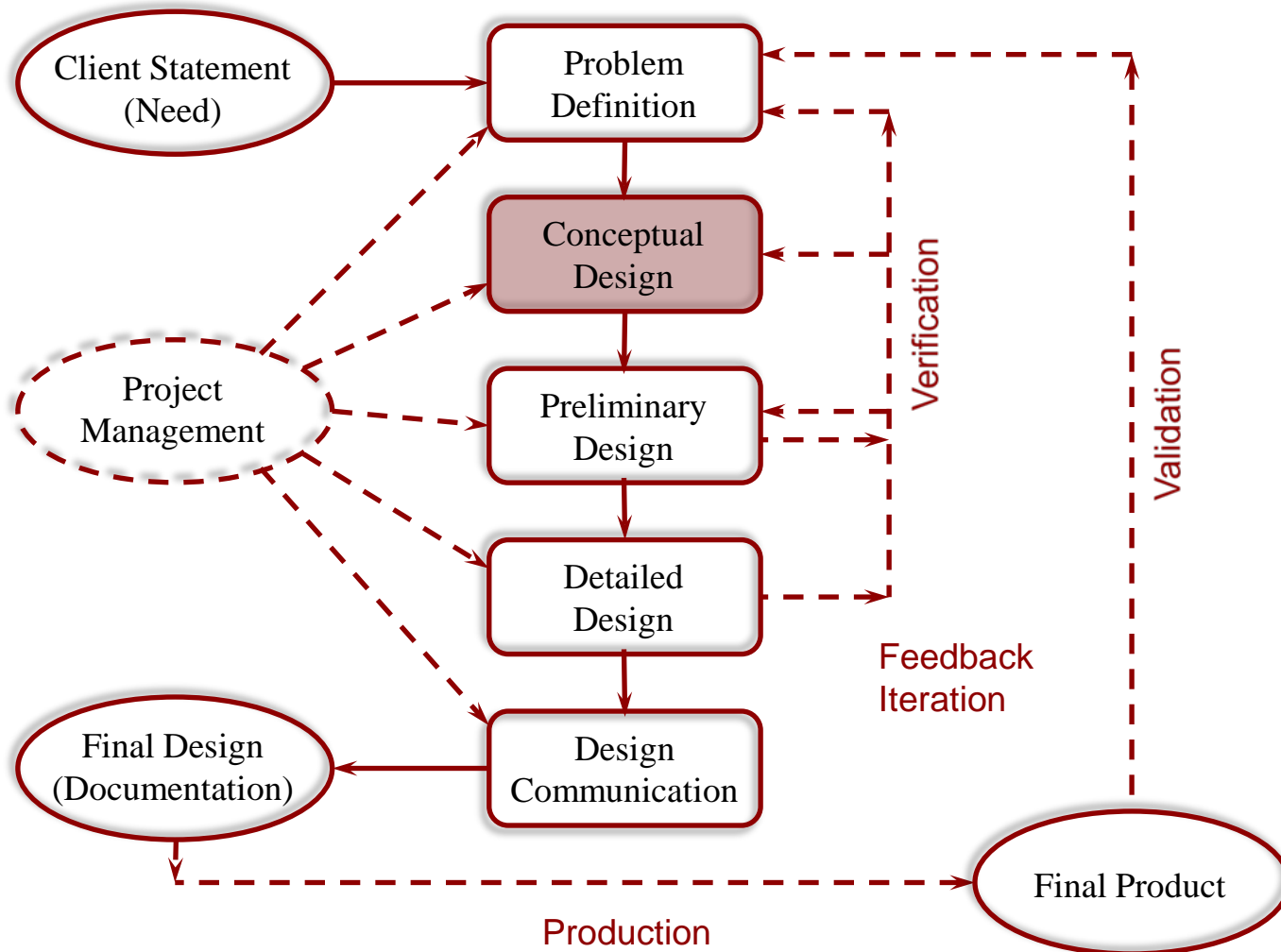
Instructor:

Dr. Flavio Firmani

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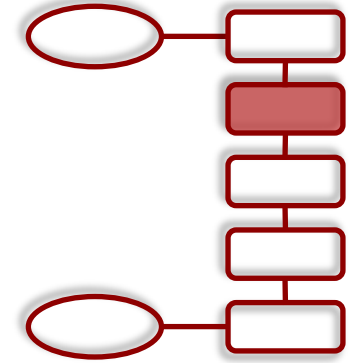
# Engineering Design Process

The design process can be modeled in five main stages.





# Conceptual Design



Here we generate concepts of alternative designs.

Input: *Revised problem statement*

*List of final objectives (criteria)*

*List of final constraints*

Tasks: v) *Establish functions*

vi) *Establish requirements or specifications*

vii) *Generate alternative designs*

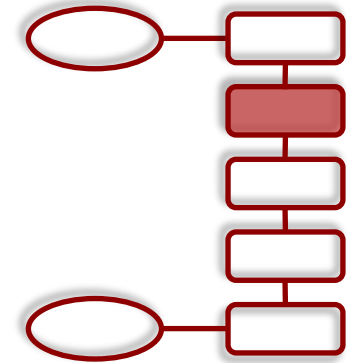
Outputs: *Design and Functional Specifications*

*Alternative conceptual designs*



# Functional Analysis

## Example of a function-means tree for the juice container



Functions

What we must do

Means

How we might do it

Design a new product that  
enters the competitive  
juice market for children

Safe Beverage  
Container

Contain Juice

Preserve Taste  
(Material)

Provide Access  
to Juice

Display of Product  
Information

Can

Bottle

Aluminum

Plastic

Glass

Pull-Tab

Inserted  
Straw

Twist Top

Shape

Label

Box

Bag

Waxed  
Cardboard

Lined  
Cardboard

Mylar Films

Tear Corner

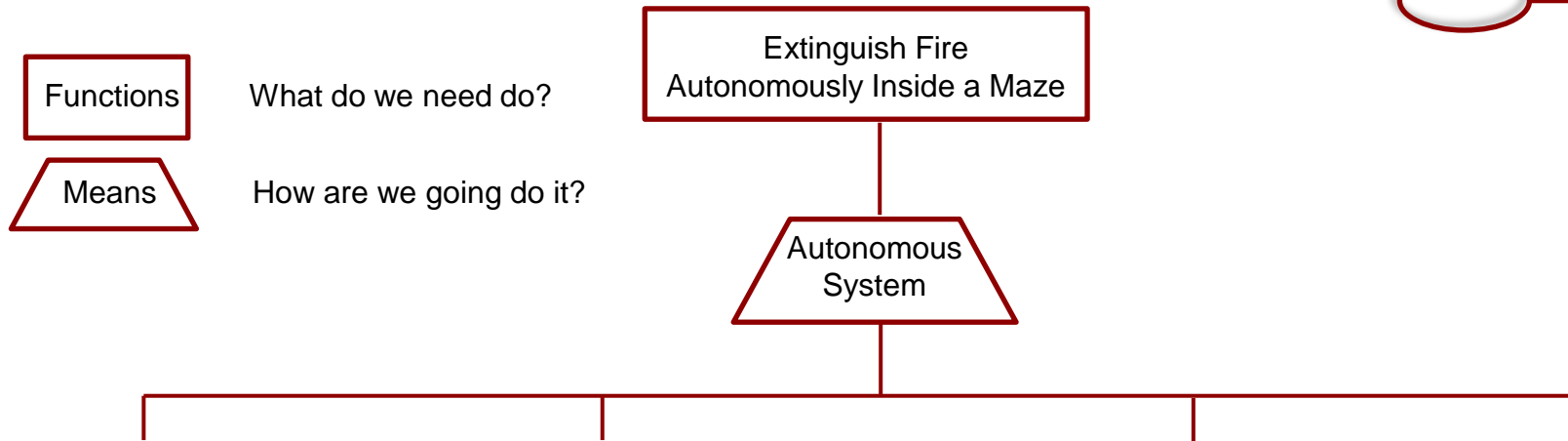
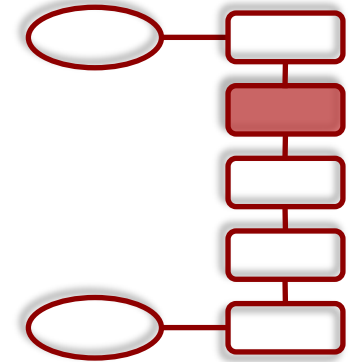
Unfold  
Container

Zipper

Colour

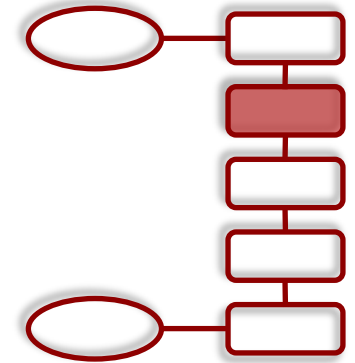


# Functional Analysis





# Conceptual Design



Conceptualization involves generating ideas (concepts), the exploration of a **design space**.

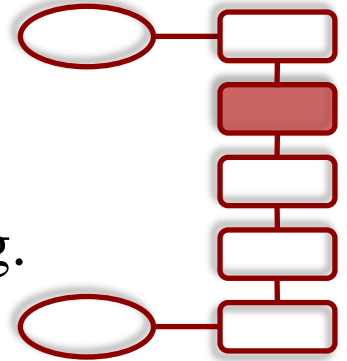
*Convergent thinking* is the type of thinking that focuses on coming up with the single, well-established answer to a problem.

*Divergent thinking* is the method used to generate creative ideas by exploring many possible solutions.

| Convergent (Vertical) Thinking      | Divergent (Lateral) Thinking   |
|-------------------------------------|--------------------------------|
| Goal: <b>Selecting</b> an Idea      | Goal: <b>Generating</b> Ideas  |
| Focuses on right or wrong           | No right or wrong              |
| Sequential                          | All over the place             |
| Excludes all irrelevant information | Accepts all the information    |
| Tries to finalize                   | Tries to open the design space |



# Conceptual Design

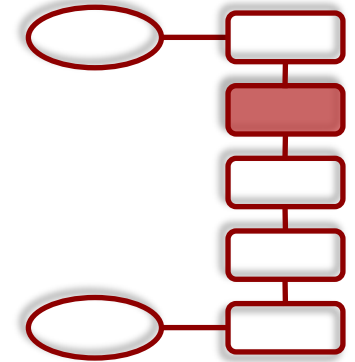


Design combines divergent and convergent thinking. The design process seeks to converge upon the ‘best’ possible solution. However, in order to establish a pool of ideas in which we can select the ‘best’ solution requires divergent thinking.

*“Invention is 99% perspiration (sweating/work) and 1% is inspiration.”* Thomas Edison

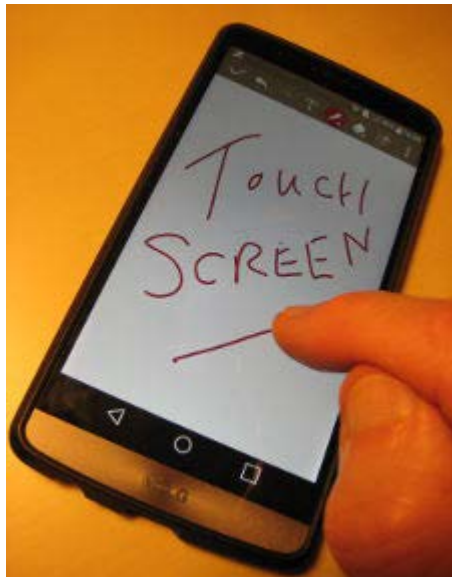


# Conceptual Design



This stage of the design process is what leads to **creativity** and **innovation**.

Many of the most creative ideas were criticized because they were not “conventional”.



*Nicholas Negroponte, founder of MIT's Media Lab, predicted (1984) that electronic devices were going to be interacted with fingers. Critics argued that fingers would dirty screens and never be used.*

*Steve Jobs, introducing the iPhone (2007)*

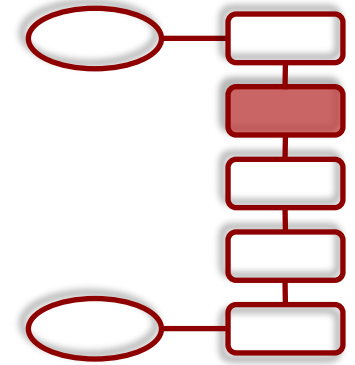
*STEVE JOBS: Oh, a stylus, right? We're going to use a stylus? No.*

*STEVE JOBS: No. Who wants a stylus? You have get and put them away and you lose them. Yuck. Nobody wants a stylus.*





# Conceptual Design



Think of different ways of opening a bridge so small boats can pass through.

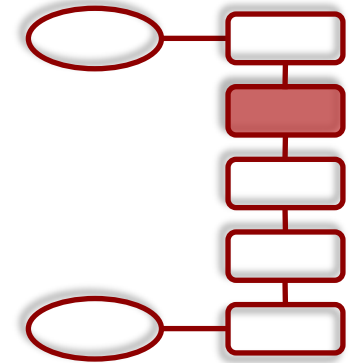


Johnson St Bridge (new), Victoria

Johnson St Bridge (old), Victoria



# Conceptual Design



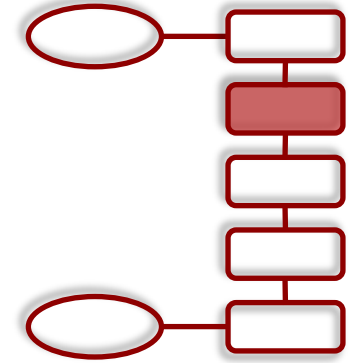
Generating design concepts is exciting but also challenging.

Brainstorming is a key aspect of conceptualization. However, team members may have different ideas and generally focus on specific technical sub-elements, making conflict almost inevitable.

There is no method that always works. Sometimes we need to try different methods.



# Conceptual Design

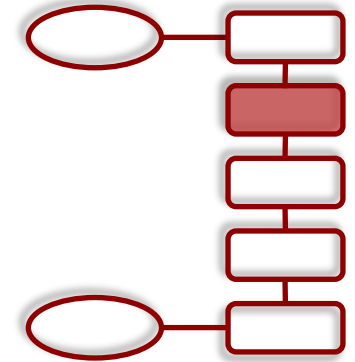


## Rules for Brainstorming

- **Capture all ideas.** Make sure to write down every idea. There are no stupid ideas, encourage wild ideas.
- **Defer all judgement,** on other people's ideas and your own.
- **Build off the ideas of others.** It is important to listen and participate.
- **Be visual,** create diagrams that allow you to communicate better
- **One conversation at a time.** Respect other people.
- **Go for quantity.** Try to develop as many ideas as possible



# Conceptual Design

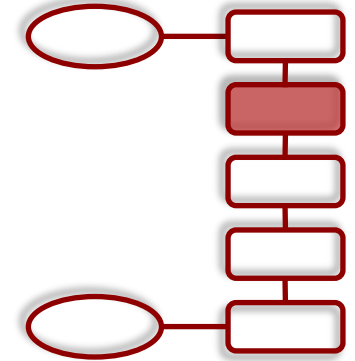


## Tips for Brainstorming

- **Be Prepared.** Before you begin the brainstorming session, make sure that you have already thought about some ideas.
- **Divergent Thinking.** Try to develop as many ideas as possible, without converging (avoid thinking about details of a single idea).
- **Be Respectful.** It is important to listen and to be listened.
- **Have Breaks.** When many ideas are presented, it is hard to keep up with all of them.



# Conceptual Design



## Methods to Generate Ideas

### The 6-3-5 method

The name comes from 6 team members, who each write a list of 3 design ideas, and each list is circulated among all the remaining 5 members for written comments on the ideas. This technique can be generalized as the  $m-3-(m-1)$  method.

### The C-Sketch method

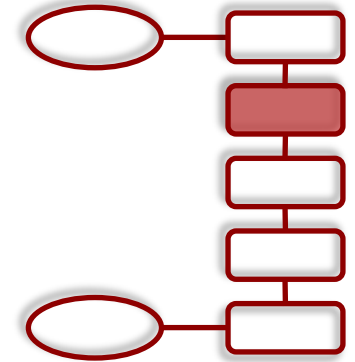
This method consists of having each member sketch an idea, and then the sketch is circulated among the members who comment on it.

### The Gallery method

Each member draws an idea and then all the ideas are displayed together where the members have an open group discussion.



# Conceptual Design



## Methods to Generate Ideas

### Synectics (analogies)

Find new ideas by looking at solutions from other problems.

Say, you want to find new ideas on how to make the emergency room of a hospital more efficient.

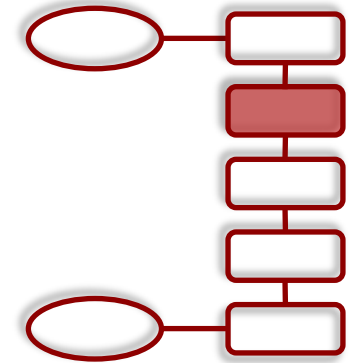
A scenario with similar situations happen in the pit stops of car racing. Both of these scenarios are time based, deal with emergencies (some of which are unexpected), and the staff/crew must be very well organized.







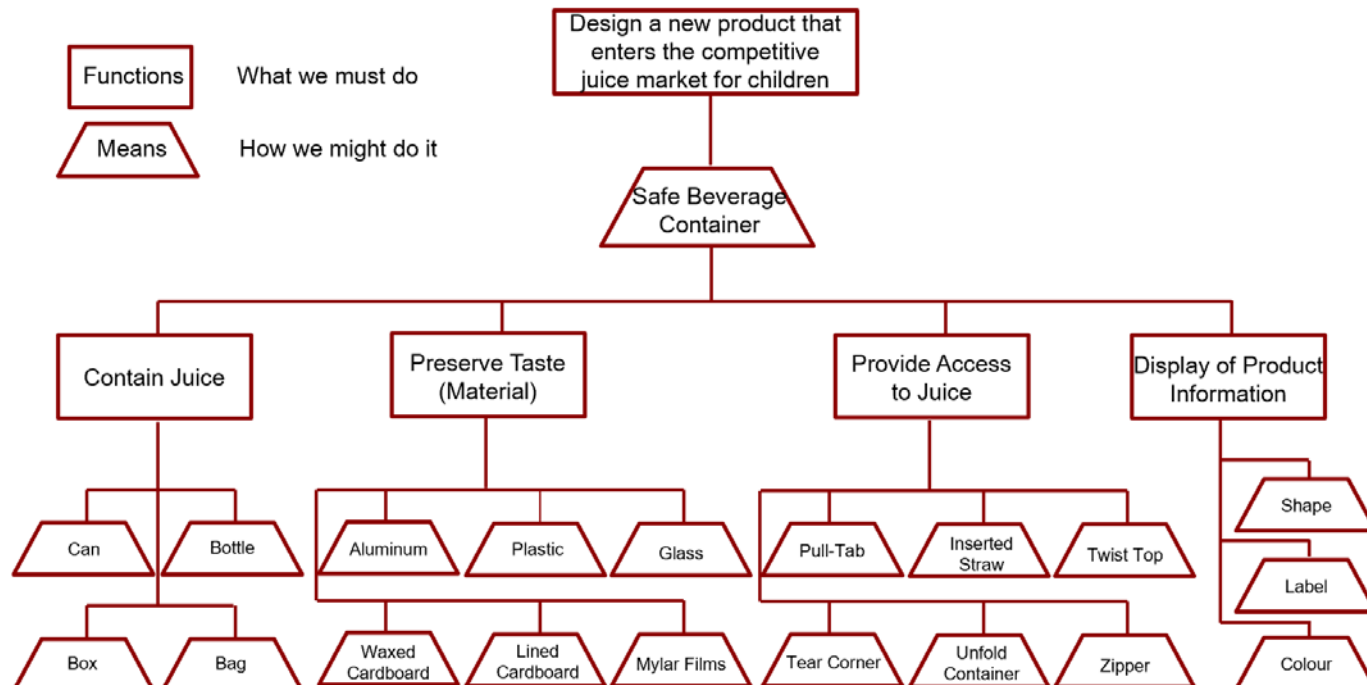
# Conceptual Design



## Methods to Generate Ideas

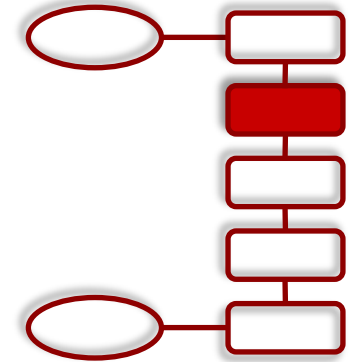
### Morphological Charts

Morphological Charts provide another way to visualize elements of a design space. It can be seen as a continuation of the function-means tree. Use functions or features that are at the same level.





# Conceptual Design



## Morphological Charts

*List functions (same level):*

*List all the means*

*Contain beverage:*

*Can, Bottle, Bag, Box*

*Material of container (taste, strength):*

*Aluminum, Plastic, Glass,  
Waxed Cardboard, Lined  
Cardboard, Mylar Films.*

*Provide access to juice*

*Pull-Tab, Inserted Straw,  
Twist-Top, Tear Corner,  
Unfold Container, Zipper.*

*Display product information:*

*Shape, Labels, Color*

*Manufacturing sequence:*

*Concurrent, Serial*

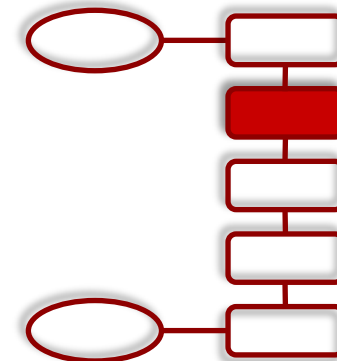
| MEANS<br>FEATURE/<br>FUNCTION            | 1                  | 2              | 3                 | 4               | 5                | 6           |
|--|--------------------|----------------|-------------------|-----------------|------------------|-------------|
| Contain Beverage                         | Can                | Bottle         | Bag               | Box             | ....             | ....        |
| Material for Drink Container             | Aluminum           | Plastic        | Glass             | Waxed Cardboard | Lined Cardboard  | Mylar Films |
| Mechanism to Provide Access to Juice     | Pull Tab           | Inserted Straw | Twist Top         | Tear Corner     | Unfold Container | Zipper      |
| Display of Product Information           | Shape of Container | Labels         | Color of Material | ....            | ....             | ....        |
| Sequence Manufacture of Juice, Container | Concurrent         | Serial         | ....              | ....            | ....             | ....        |

**FIGURE 5.1** A morphological (morph) chart for the beverage container design problem. The *functions* that the device must serve are listed in the left most column. For each function, the *means* by which it can be implemented are arrayed along a row to the function's right. A conceptual design or scheme can be constructed by linking one means for each of the five identified functions, thus assembling a design in the classic "Chinese menu" style. (See Figure 5.2.)





# Conceptual Design



## Generate concepts with Morphological charts

| MEANS<br>FEATURE/<br>FUNCTION            | 1                  | 2              | 3                 | 4               | 5                | 6           |
|--|--------------------|----------------|-------------------|-----------------|------------------|-------------|
| Contain Beverage                         | Can                | Bottle         | Bag               |                 | Box              | ....        |
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# Conceptual Design

How would you design a vehicle for blind people?

