Design for Modularity

- Design for Manufacturing

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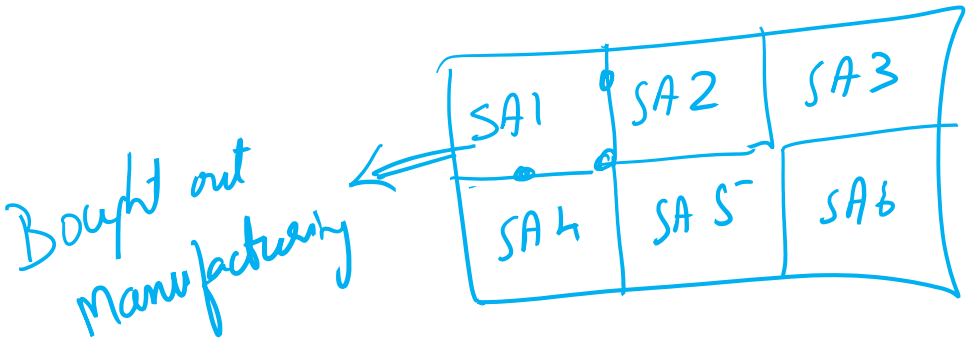
Introduction

- **Modular design** is made with an approach that subdivides a system into smaller parts called modules or skids, that can be independently created and then used in different systems.

- A modular system can be characterized by functional partitioning into
  - discrete scalable, reusable modules
  - rigorous use of well-defined modular interfaces
  - making use of industry standards for interfaces.

Electronic part ↓
Mechanical product

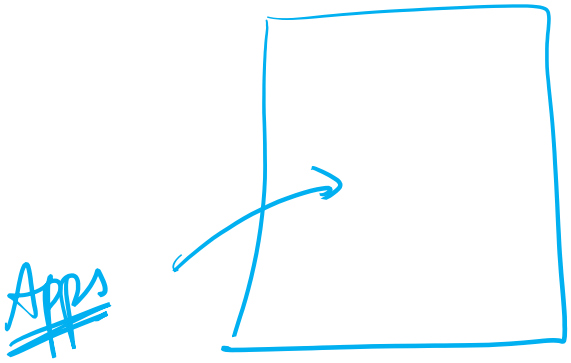


Introduction

Design for modularity can be advantageous in many ways:

std Part → Cost ↓

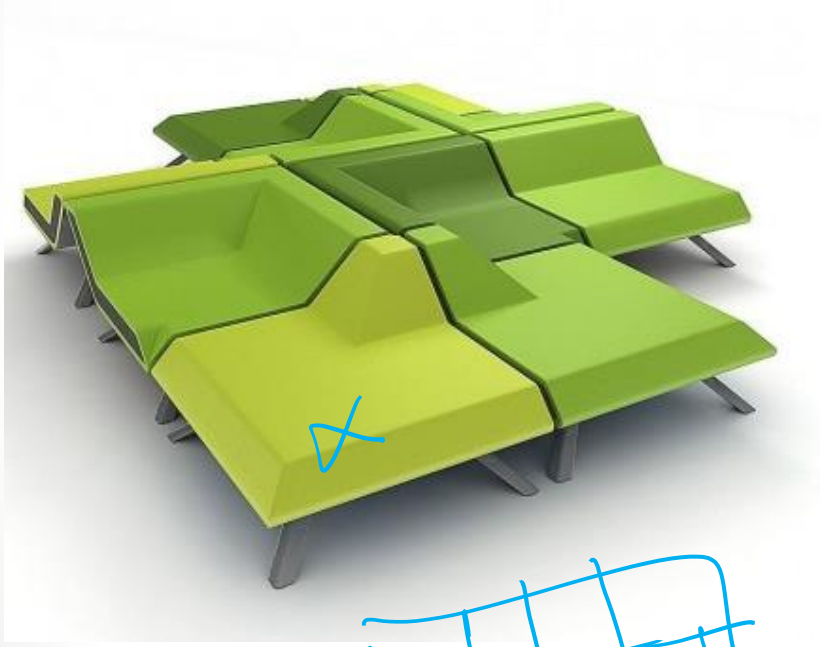
- reduction in cost (due to less customization, and shorter learning time),
- flexibility in design,
- augmentation (adding new solution by merely plugging in a new module), and
- exclusion.



Introduction

furniture

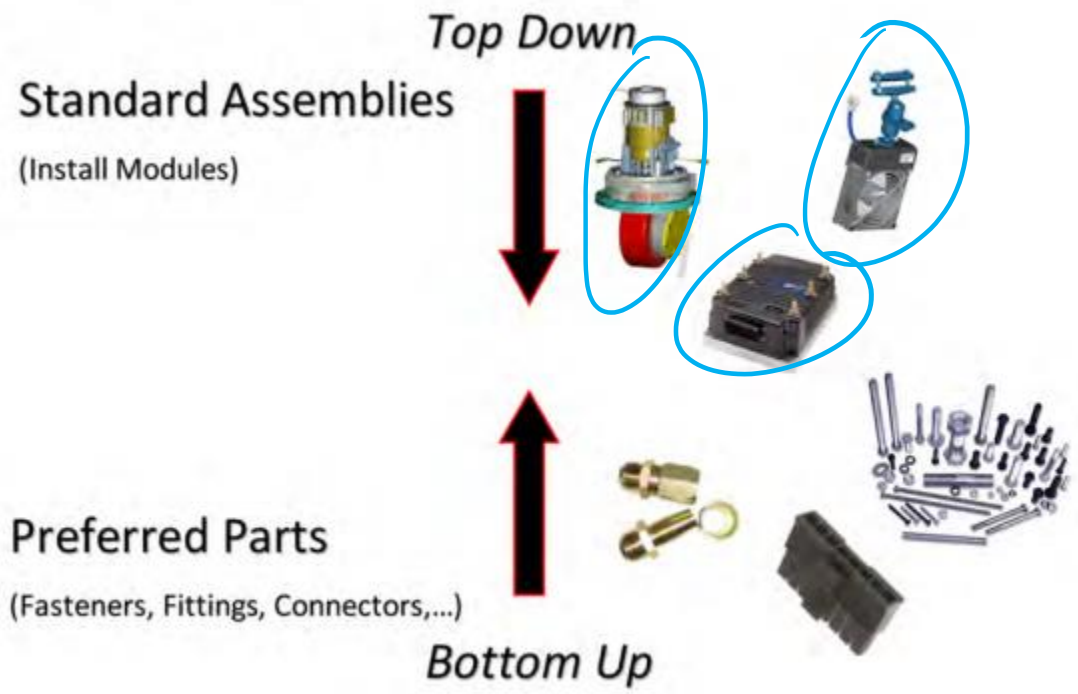
Design for modularity example:



http://mathart.wikidot.com/art-and-modularity
https://www.dezeen.com/tag/modular-furniture/

Introduction

Bottom-up and Top Down Modularity



https://www.dfma.com/pdf/designformodularity.pdf

Introduction

Before discussing the ‘Design for Modularity’, the concepts of ‘Design for Manufacturing’ and ‘Design for Assembly’ need to be known.

This module is divided into these lectures:

1. Design for Manufacturing
2. Design for Assembly
3. Design for modularity

Design for manufacturing

Definition

- Design for manufacturing (DFM) is a design technique for manufacturing ease of an assortment of parts that would constitute the final product after assembly.

- Design for manufacturing focuses on minimizing the complexities involved in manufacturing operations as well as reducing the overall part production cost.

Design for manufacturing

Design for manufacturability

Design for Manufacturing is also the process of proactively designing products to:

1. Optimize all the manufacturing functions:
   - fabrication,
   - assembly,
   - test,
   - procurement,
   - shipping,
   - delivery,
   - service, and
   - repair,

Design for manufacturing

Design for manufacturability

Design for Manufacturing is also the process of proactively designing products to:

2. Assure the best
   - cost,
   - quality,
   - reliability,
   - regulatory compliance,
   - safety,
   - time-to-market, and
   - customer satisfaction.

Design Review

Concurrent engineering
Digital platform

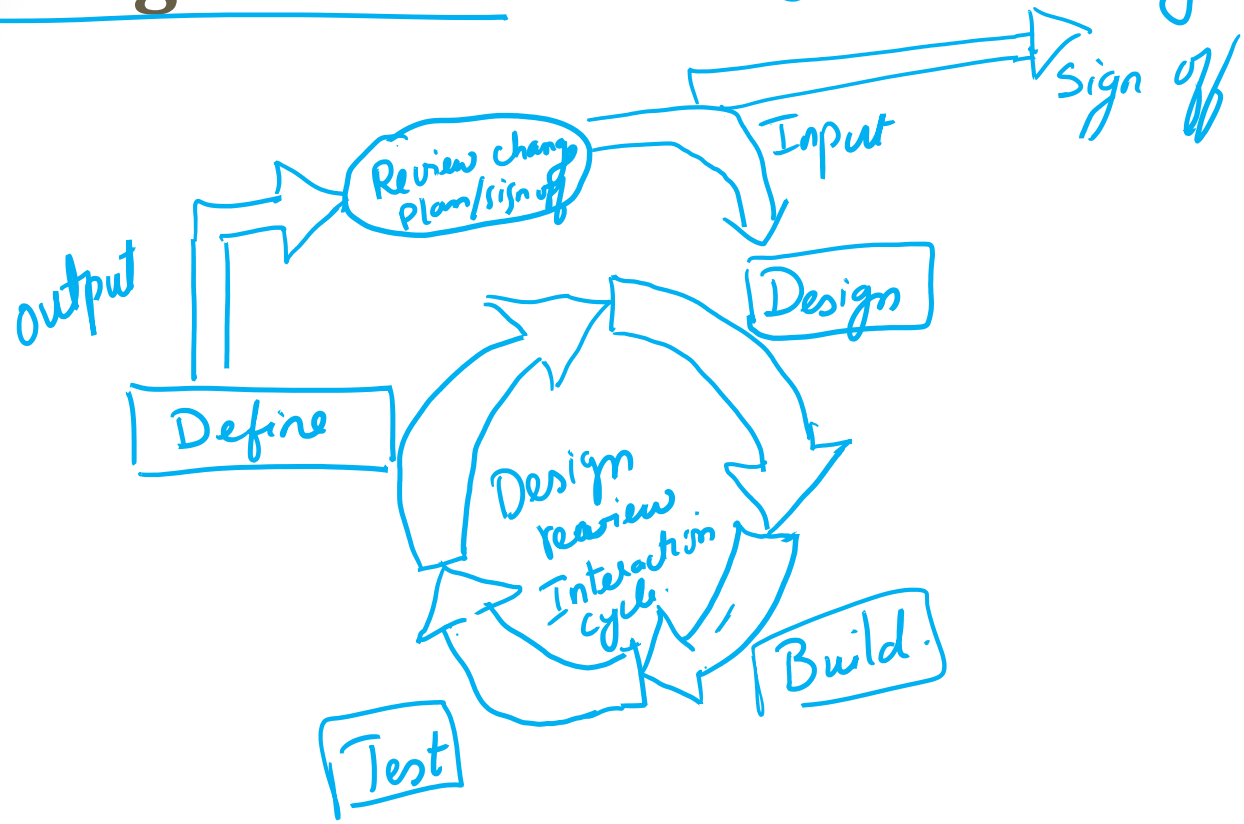
The purpose of a design review is:

- to provide a systematic and thorough product-process analysis,
- a formal record of that analysis,
- feedback to the design team for product and process improvement.

Some commonly associated problems with the implementation of the design review process are:

- Unevenly matched skills and knowledge among the design review team.
- Lack of communication between product developers and the related departments.
- No time to make design-review-based changes.
- Lack of design review experience.
- Each department considers design review a separate stage and not included in the initial design process.

Design Review :- Schematic diagram.



Design Review

Soft-Hard Review:

- The soft-hard (SH) review addresses the need to design a product for safety, that is, in terms of the real-world conditions.
- The soft reviews look into the careless misuse of products by users, beyond normal wear and tear.

Failure Mode and Effects Analysis; (FMEA)

- The basic method is to describe the parts of a system and list the consequences if each part fails.
- In most formal systems, the consequences then are evaluated by this criteria and associated risk indices:
  - severity (S),
  - likelihood of occurrence (O) or
  - probability of occurrence (P), and
  - inability of controls to detect it (D).

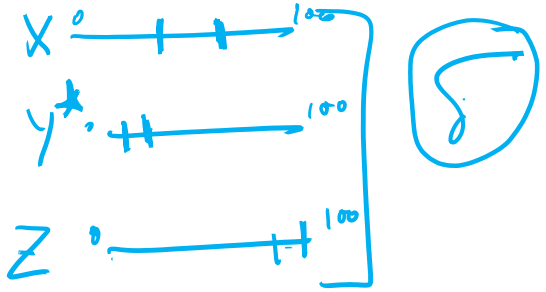
Design Review

Experimental Design:

- The objective is to determine those variables in a process or product that form critical parameters and their target values.
- By using formal experimental techniques, the effect of many variables can be studied at one time.

There are six basic steps of the same-

1. Establish the purpose.
2. Identify the variables.
3. Design the experiment.
4. Execute the experiment.
5. Analyse the results.
6. Interpret and communicate the analysis.



- individual effect
- combined effect

Why DFM?

- The DFM methodology allows for new or improved products to be designed, manufactured and offered to the consumer in a shorter amount of time.
-
- DFM helps eliminate multiple revisions and design changes that cause program delays and increased cost.
- With DFM the design is often more comprehensive, efficient to produce and meets the customer requirements the first time.

How to Perform DFM?

- Many companies today are integrating the DFM and DFA practices through design and manufacturing teamwork.
- The Design for Manufacturing (DFM) and Design for Assembly (DFA) techniques are two different classifications.
- DFM techniques are focused on individual parts and components with a goal of reducing or eliminating expensive, complex or unnecessary features which would make them difficult to manufacture.
- DFA techniques focus on reduction and standardization of parts, sub-assemblies and assemblies.
- The goal is reduce the assembly time and cost.

Design for Manufacturing guidelines:

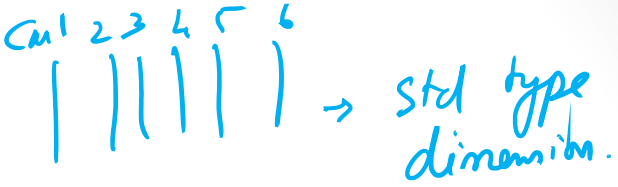
Minimize number of components:

- Assembly costs are reduced.
- The final product is more reliable because there are fewer connections.
- Disassembly for maintenance and field service is easier.
- Reduced part count usually means automation is easier to implement.
- Work-in-process is reduced, and there are fewer inventory control problems.
- Fewer parts need to be purchased, which reduces ordering costs.

Use standard commercially available components:

- Design time and effort are reduced.
- Design of custom-engineered components is avoided.
- There are fewer part numbers. Inventory control is facilitated.
- Quantity discounts may be possible.

Design for Manufacturing guidelines:



Use common parts across product lines:

- There is an opportunity to apply group technology.
- Implementation of manufacturing cells may be possible.
- Quantity discounts may be possible.

Design for ease of part fabrication:

- Net shape and near net shape processes may be feasible.
- Part geometry is simplified, and unnecessary features are avoided.
- Unnecessary surface finish requirements should be avoided; otherwise, additional processing may be needed.

Design for Manufacturing guidelines:

Design parts with tolerances that are within process capability:

- Tolerances tighter than the process capability should be avoided; otherwise, additional processing or sortation will be required.
- Bilateral tolerances should be specified.

Design the product to be foolproof during assembly:

- Assembly should be unambiguous. → PCB + charger to your phone
- Components should be designed so they can be assembled only one way. Special geometric features must sometimes be added to components to achieve foolproof assembly.

Minimize use of flexible components:

- Flexible components include parts made of rubber, belts, gaskets, cables, etc.
- Flexible components are generally more difficult to handle and assemble.

Task for students

- Look at a automobile of your choice and list down the std part used (go upto to sub assembly only)
- Look at a Ball-point pen and list down its variants
- Look at a Customized product and apply your knowledge on individual parts and make the design more modular.

Thanks