

Design for Modularity

Dr. Janakarajan Ramkumar

Professor

Department of Mechanical & Design Program

IIT Kanpur, India.

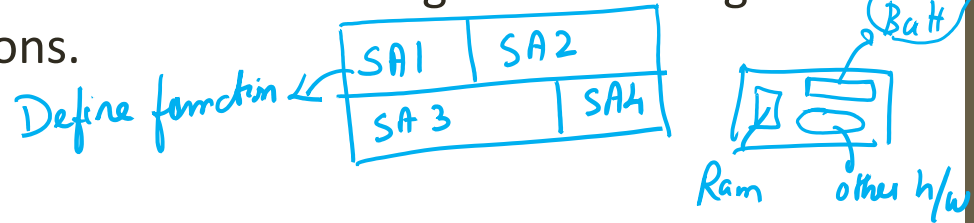
Content

- **Modules**
- **Modular Design**
- **Modularity**
- **Design for Modularity**
- **DFMo architecture**

Introduction (quick recap)

Modular design is a design technique that can be used to develop complex products using similar components. / *simpler sub-assembly.*

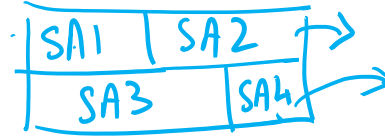
- Modular design can be viewed as the process of producing units that perform discrete functions, and then connecting the units together to provide a variety of functions.



- Components used in a modular product must have features that enable them to be coupled together to form a complex product.
- Modular design can be viewed as the process of producing units that perform discrete functions, then connecting the units together to provide a variety of functions.

Introduction (quick recap)

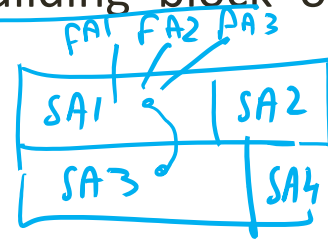
- Modular design emphasizes the minimization of interactions between components, which will enable components to be designed and produced independently.



- Each component **designed for modularity** is supposed to support one or more functions.
- When components are structured together to form a product, they will support a larger or general function.
- This shows the importance of analyzing the product function and decomposing it into sub-functions that can be satisfied by different functional modules.

Modules

Modules are a structurally independent building block of a larger system with well-defined interfaces.



They have the following characteristics:

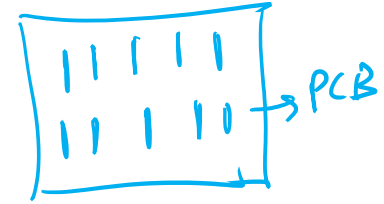
- They are co-operative subsystems that form products, manufacturing systems, and so on.
- Functional interactions occur within rather than between modules.
- They have one or more, well-defined functions that can be tested in isolation from the system and are a composite of components of the module.
- They are independent and self-contained, and can be combined and configured with other modules to achieve overall function.

Modularity

Modularity can be applied in the areas of

- product design, ✓
- design problems, ✓
- production systems, or ✓
- all three

Modularity



- **Modular products** are products that fulfill various overall functions through:
 - the combination of distinct building blocks or modules,
 - in the sense that the overall function performed by the product can be divided into sub-functions
 - that can be implemented by different modules or components.
- An important aspect of modular products is the creation of a basic core unit to which different elements (modules) can be fitted, thus enabling a variety of versions of the same module to be produced.

Auto → Basic module 

Modularity

- objective statement
→ Generic in nature
- mile stone → sub mile stone
- time frame

- For modularity, **design problems** can be broken down into a set of easy-to-manage simpler sub-problems.
- Sometimes complex problems are reduced into easier sub-problems, where a small change in the solution of one sub-problem can lead to a change in other sub-problems' solutions.

- This means that the decomposition has resulted in functionally dependent sub-problems.

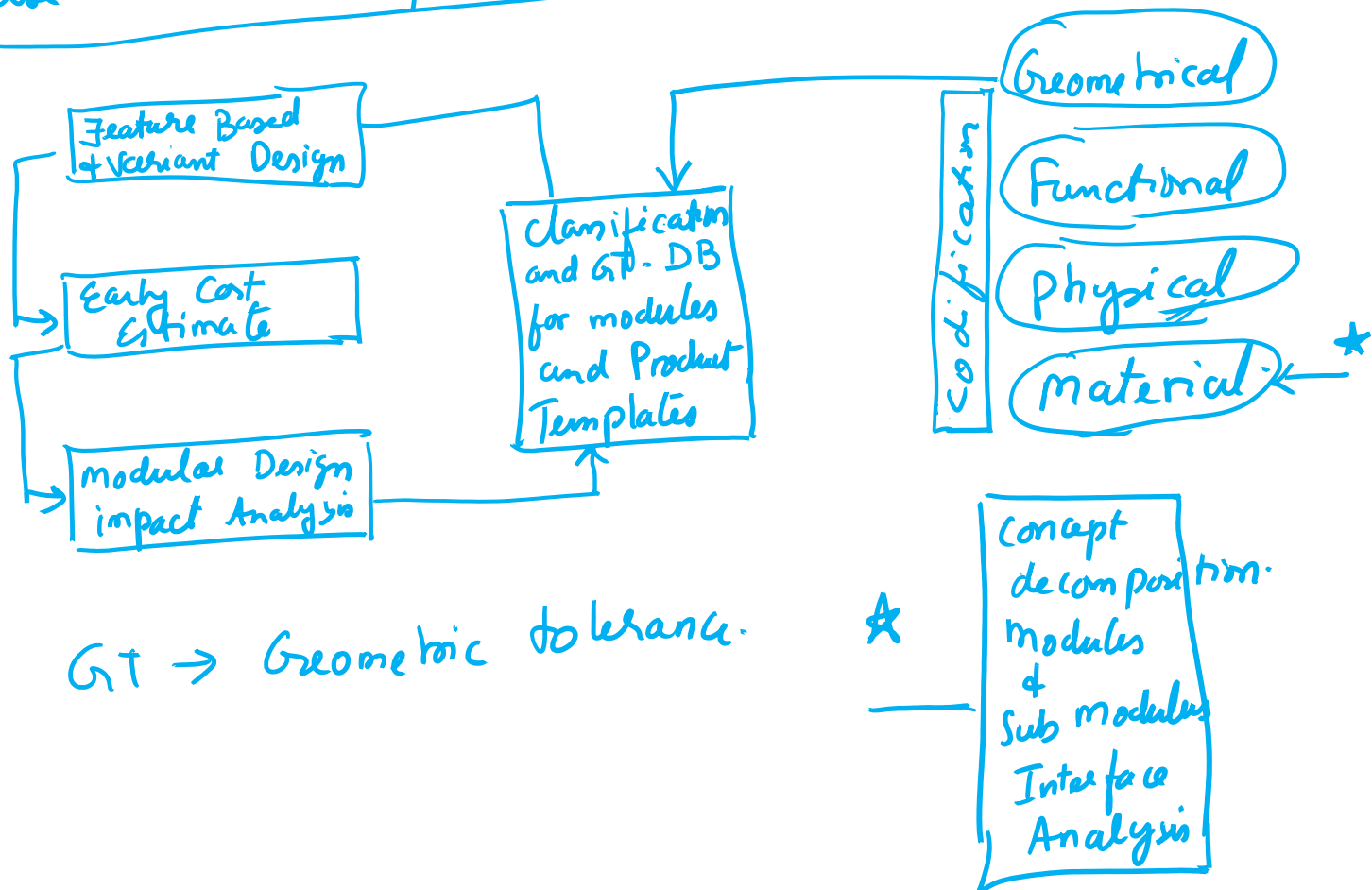
Design for Modularity

- A three-phase methodology can be devised for 'Design for Modularity', for the development of complex products using the modularity concept.
- The methodology matches the criteria set by:
 - the design for assembly, and
 - the design for manufacture.
- Illustration in the next slide gives an overview of the product design sequence in the proposed methodology.

Design for Modularity

Design for Modularity architecture

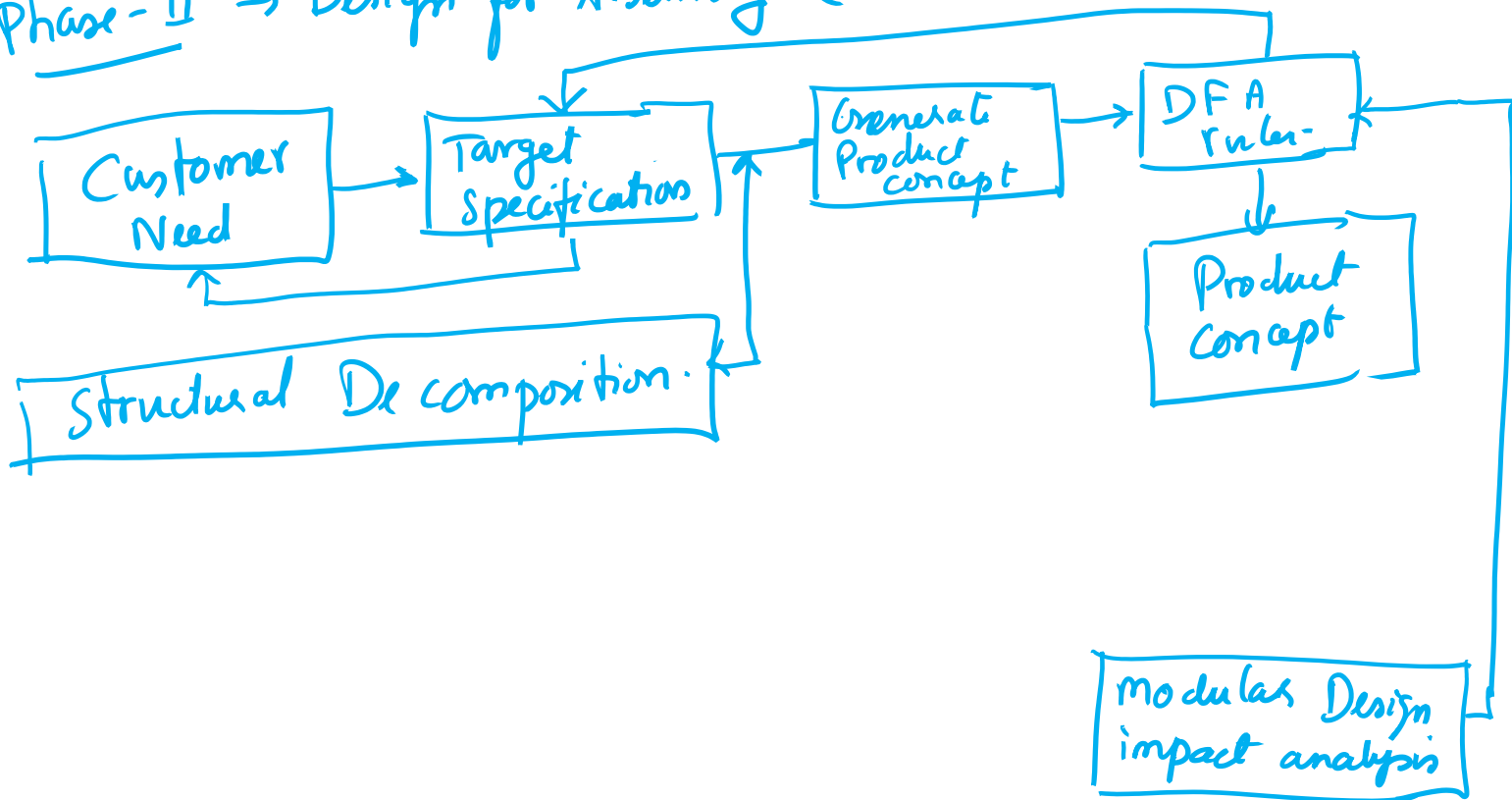
Phase - I → Decomposition and DFM_o



Design for Modularity

Design for Modularity architecture

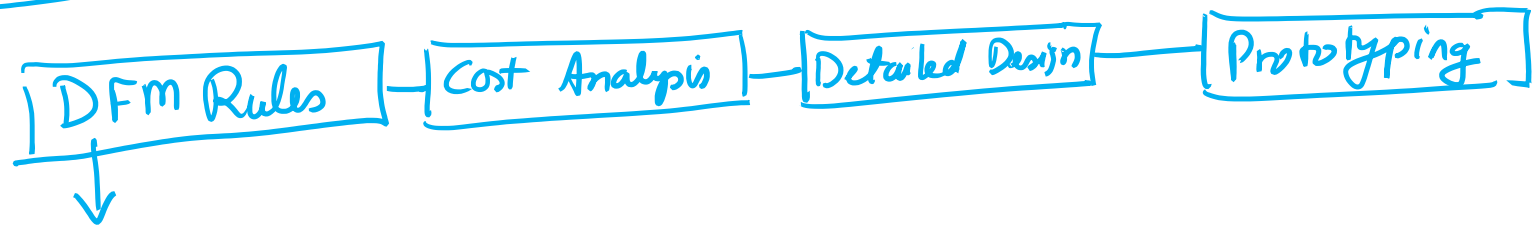
Phase-II → Design for Assembly (DFA)



Design for Modularity

Design for Modularity architecture

Phase - III



Design for Manufacturing

Design for Modularity

(library) for sub assembly
function

- Some of the major benefits associated with this methodology include:
- Increased design accuracy and efficiency and the reuse of existing design for new programs.
- Potential for integration of the developed methodology and technology into the engineering design activities.
- Modular product design and the process of planning the production are integrated in one overall engineering process in which product features are mapped into their feasible process(es) in a one-to-one correspondence.

Design for Modularity

Phase I:

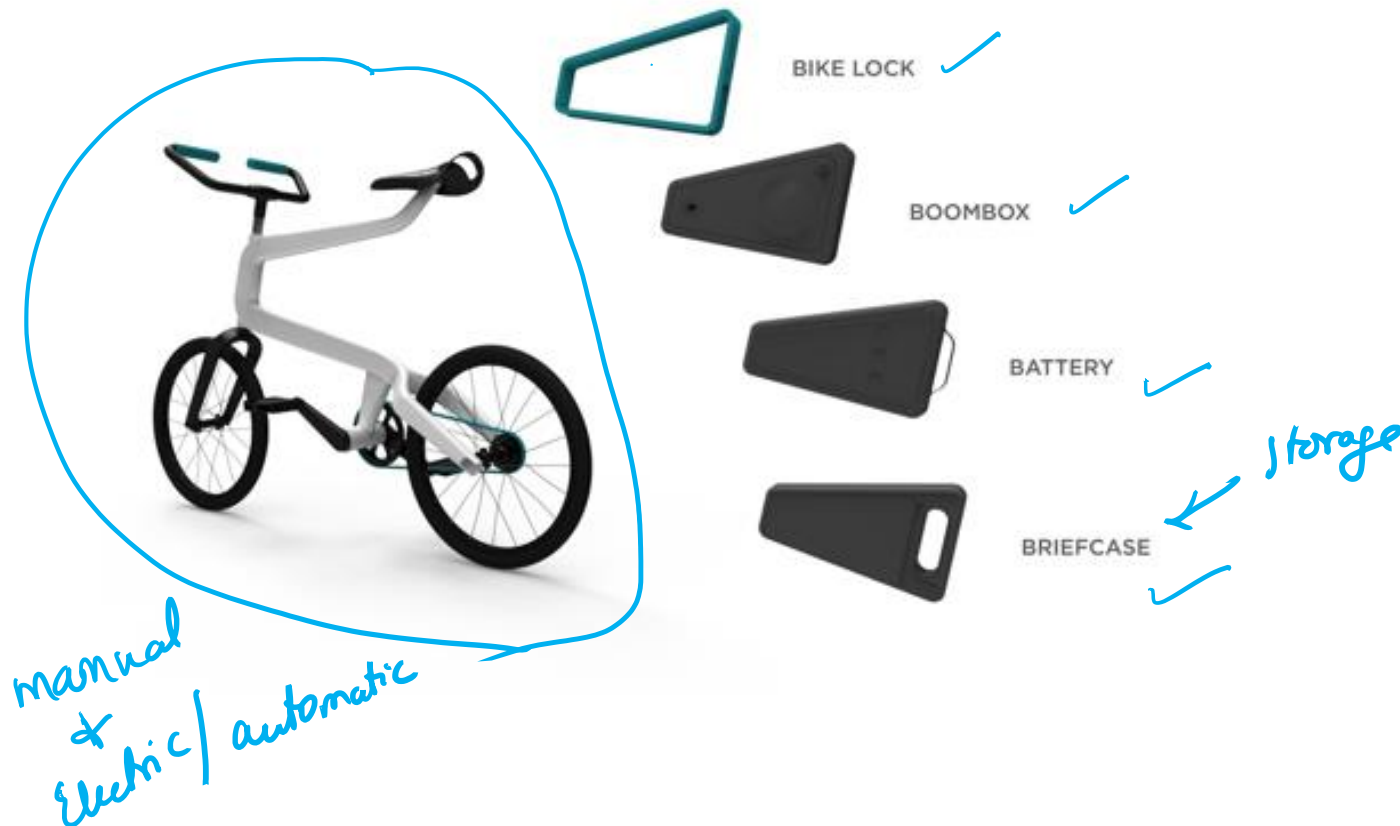
Decomposition Analysis: Design for Modularity and Classification (DFMo)

- Product and problem decomposition
- Structural and modular decomposition
- Associativity analysis between the components and specifications
- Application of group technology classification system (Group technology)
 - based on
 - feature (similar)
 - manufacturing (similar)
- Construction of the associativity measure matrix
- Optimum module selection

Design for Modularity

Phase I:

Decomposition Analysis: Design for Modularity and Classification (DFMo)



Design for Modularity

Phase II:

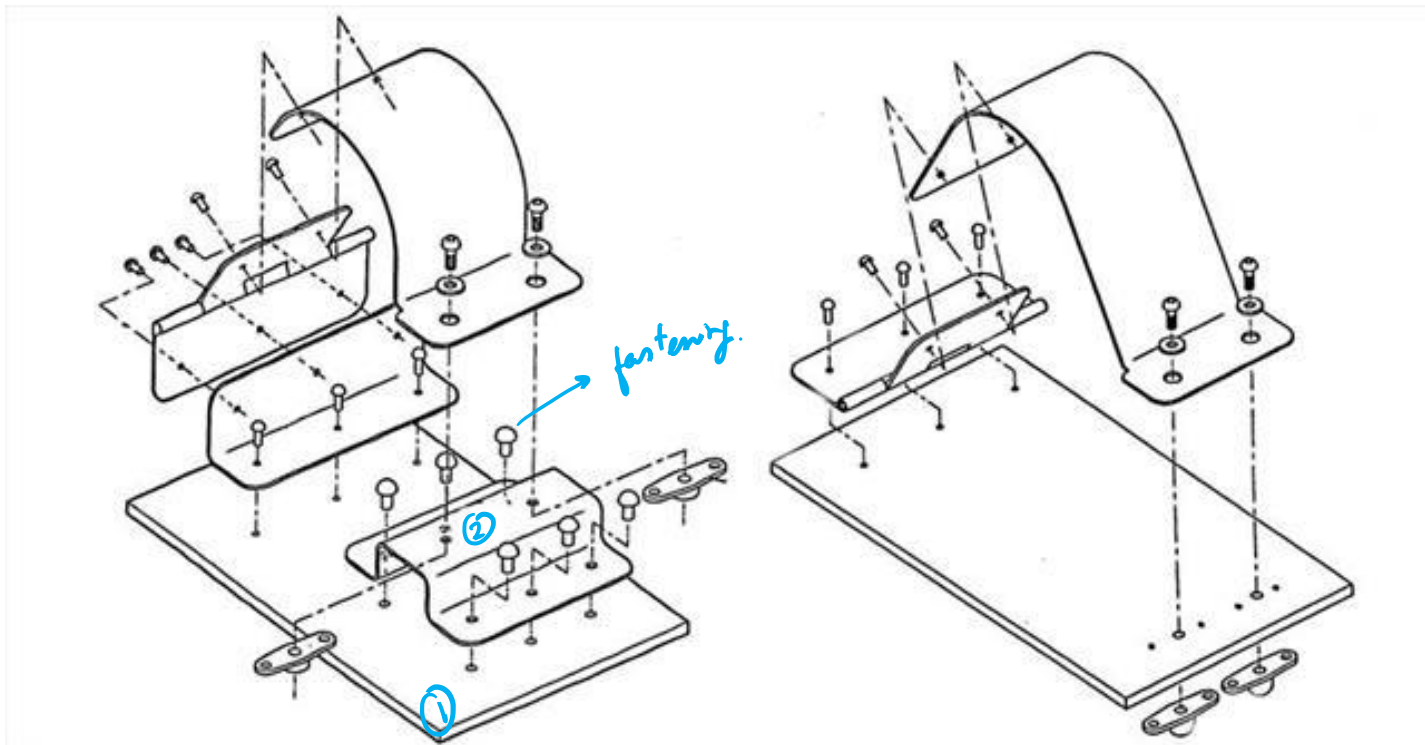
Product Analysis: Design for Assembly and Functionality Analysis

- Identify the components that could be produced and assembled separately
- Determine the order of disassembly and assembly for each subcomponent module
- Establish the interfaces based on the analysis of the design features
- Determine the order in which the subassemblies are assembled to produce the final product

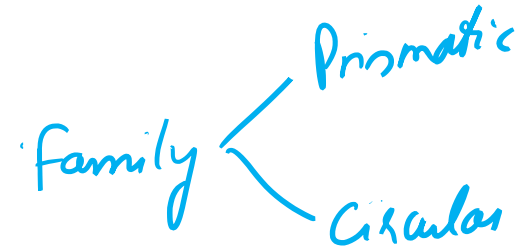
Design for Modularity

Phase II:

Product Analysis: Design for Assembly and Functionality Analysis



Design for Modularity



Phase III:

Process Analysis: Design for Manufacture

- Family identification and template retrieval
- Determination of the logical order of GT codes for the process of modules
Part → No → Xαα γγγ εεε abc
- Machine and process parameter calculation
- Variant process planning
- Phase I of this methodology (Figure below) is the focus of this chapter

Design for Modularity

Phase III:

Process Analysis: Design for Manufacture

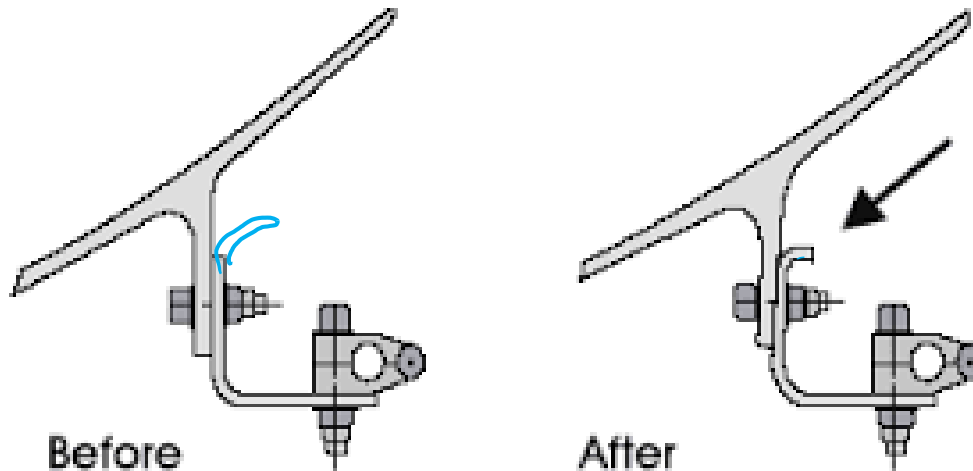
- Further specifications associated with this phase include:
- Needs analysis ✓ → *Customer*
- Requirements analysis ✓
- Concept analysis
- Concept integration

Design for Modularity

Phase III:

Process Analysis: Design for Manufacture

Bracket Design:



To recapitulate:

- **What are modules?**
- **What is Modular Design?**
- **Defining Modularity.**
- **What is Design for Modularity?**
- **How do we execute DFMo**

Task for Students

- How do you relate modular concept in manufacturing of shirt & pants
- How do you benefit by doing this modularity
- Utensil at kitchen see how modularity is followed.
- Use the concept of modularity and improve the same utensil shape/function.

Thanks