Introduction to Design Process

ME122

Portland State
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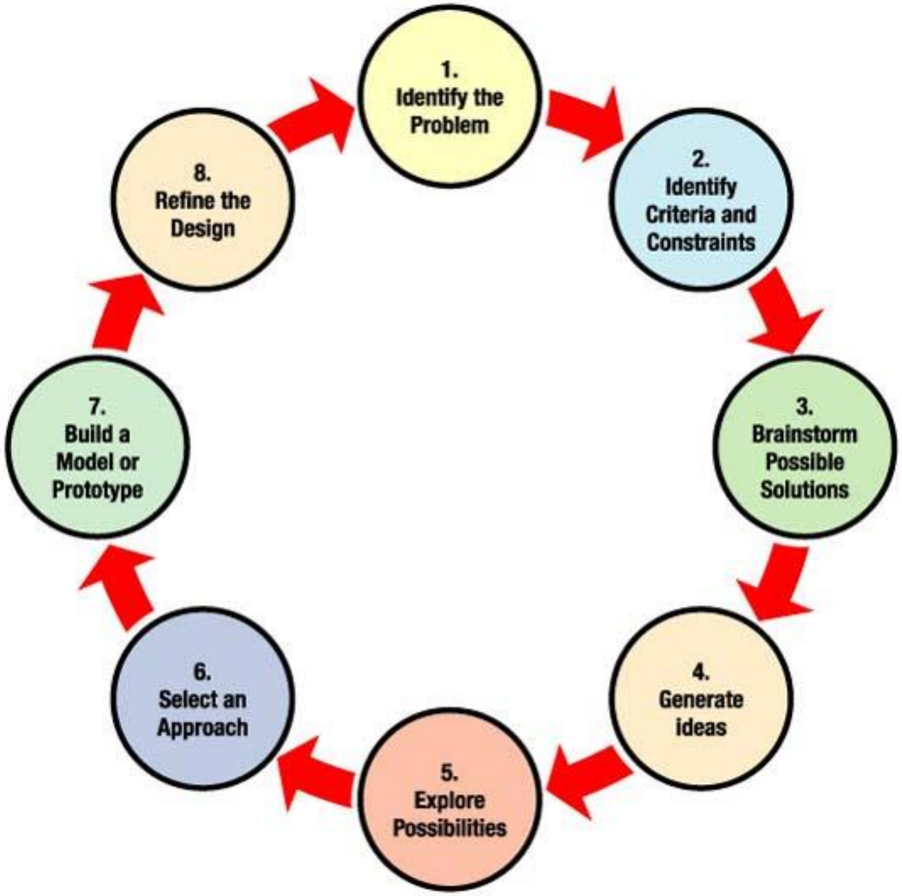
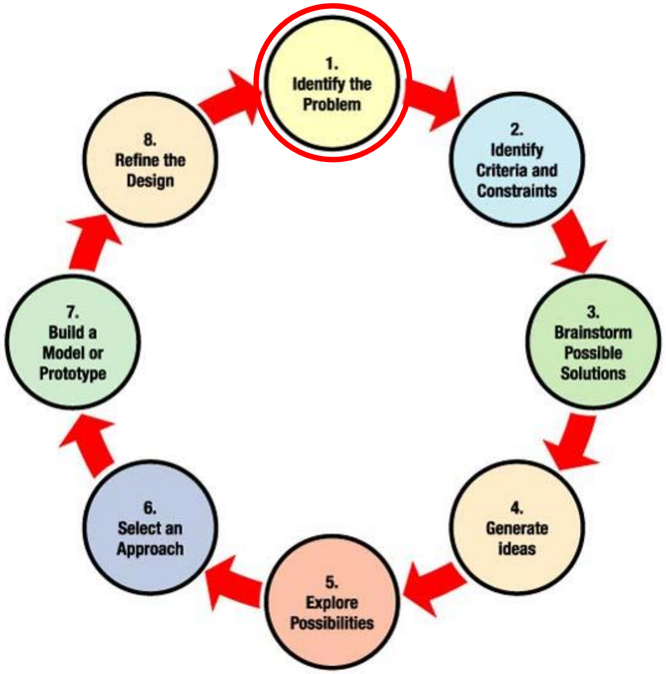
Design Process



https://www.nasa.gov

Design Process

1. Identify the problem
   - Often identified by a “customer” need.
   - Would typically be a statement such as “How can I design a _______________ that will ___________ ?



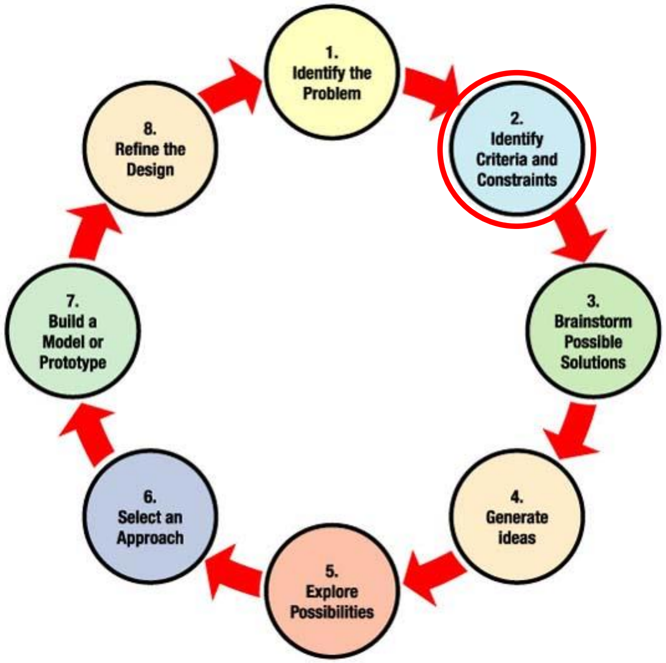
Design Process

2. Define requirements (criteria) and constraints
   – This does not mean a design solution.
   – The requirements definition process, in cooperation with the customer, identifies what the end product needs to do, and any associated constraints

- *Example of criteria (from nasa.gov): "Our growth chamber must have a growing surface of 10 square feet and have a delivery volume of 3 cubic feet or less. "*

Students should list the limits on the design due to available resources and the environment (constraints).

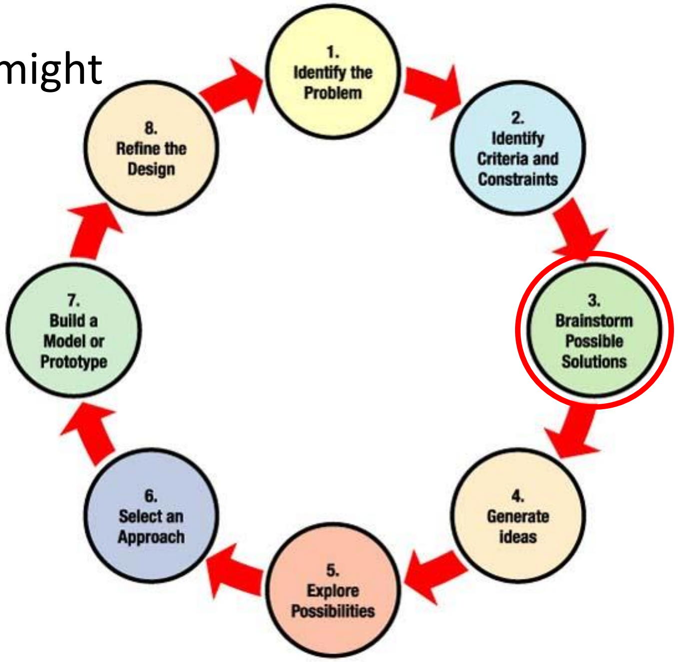
- *Example of constraint: "Our growth chamber must be accessible to astronauts without the need for leaving the spacecraft."*



Design Process

3. Brainstorm / Research
   - What is already out there? What works, what doesn't, and why?
   - What are some concepts that can be adopted for this product?

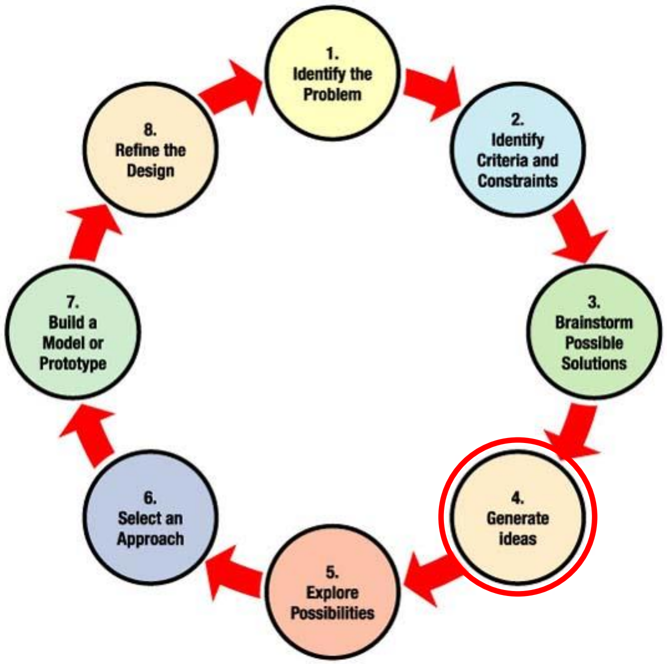
Each student in the group should sketch his or her own ideas as the group discusses ways to solve the problem. Labels and arrows should be included to identify parts and how they might move. These drawings should be quick and brief.



Design Process

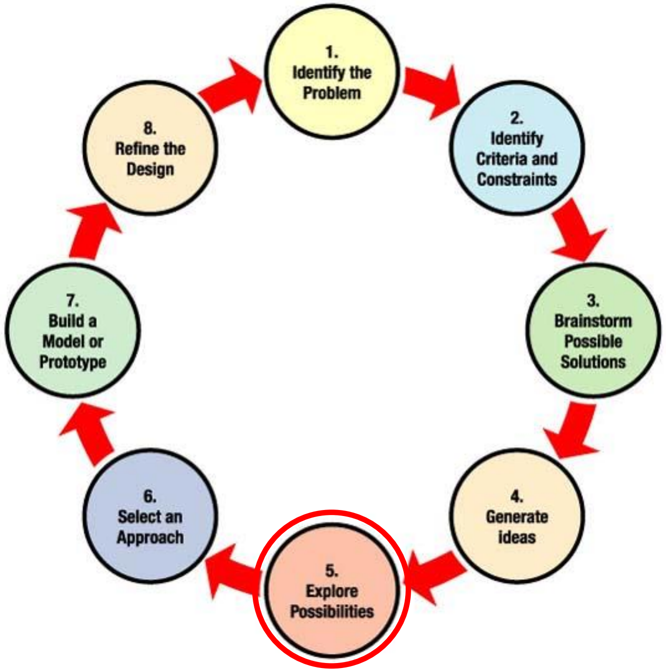
4. Generate Ideas

- In this step, each student should develop two or three ideas more thoroughly.
- Students should create new drawings that are orthographic projections (multiple views showing the top, front and one side) and isometric drawings (three-dimensional depiction).
- These are to be drawn neatly, using rulers to draw straight lines and to make parts proportional. Parts and measurements should be labeled clearly.



Design Process

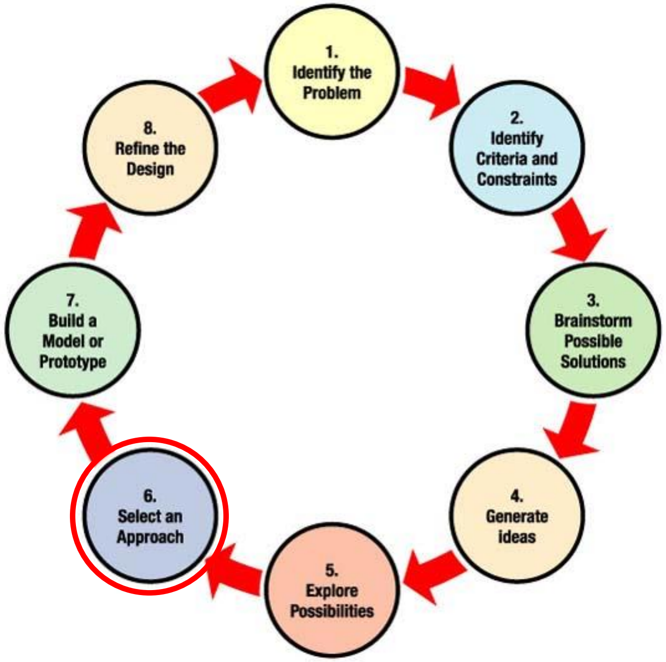
5. Explore Possibilities
   – The developed ideas should be shared and discussed among the team members.
   – Students should record pros and cons of each design idea directly on the paper next to the drawings.



Design Process

6. Select an Approach

- Students should work in teams and identify the design that appears to solve the problem the best.
- Students should write a statement that describes why they chose the solution. This should include some reference to the criteria and constraints identified previously.

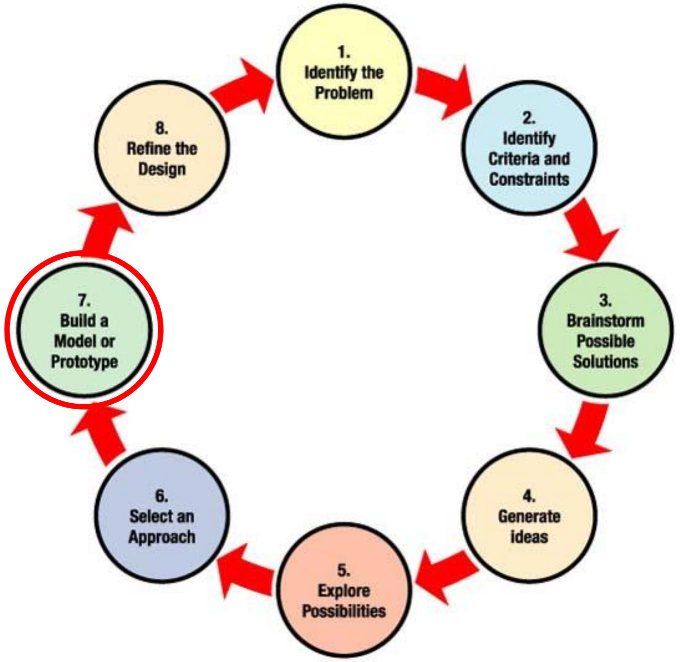


Design Process

7. Develop a prototype

Students will construct a full-size or scale model based on their drawings.

- Develop solid model
- Breadboard components / processes
- Integrate
- **Document** design, problems, limitations

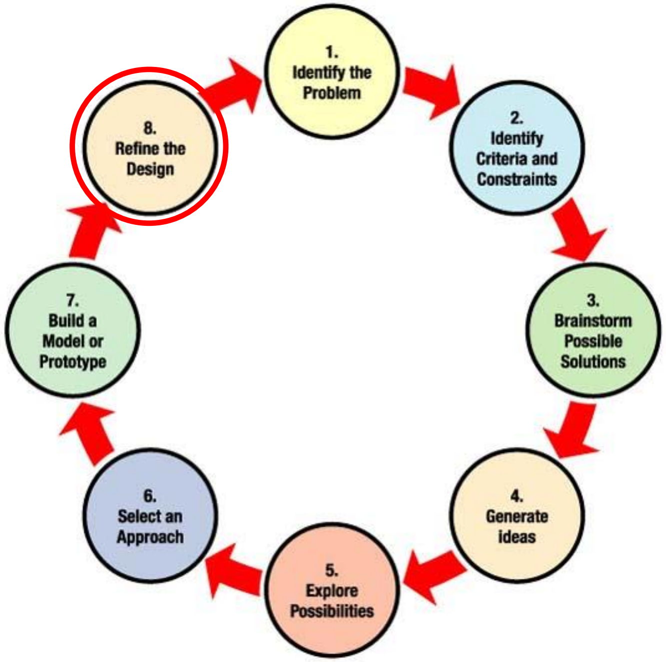


Design Process

8. Test and Refine

- Does the design meet the requirements?
- Is the design within the constraints?

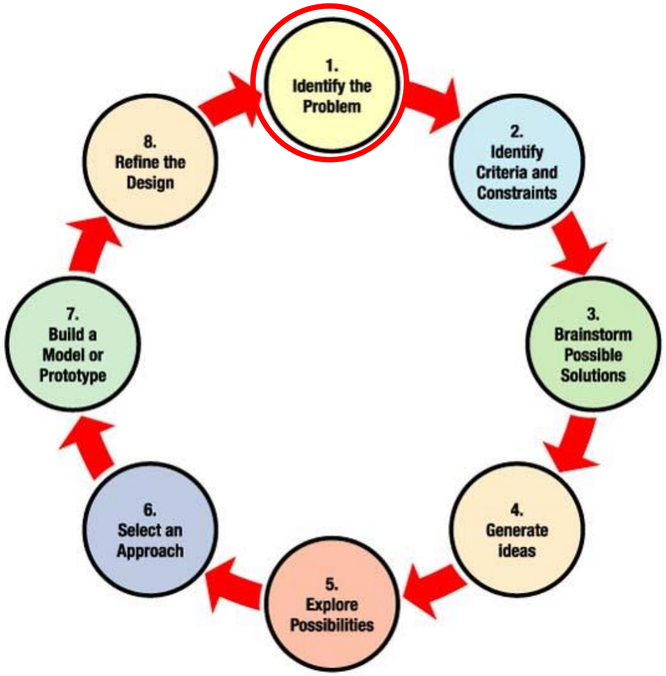
Based on criteria and constraints, teams must identify any problems and propose solutions.



Design Process

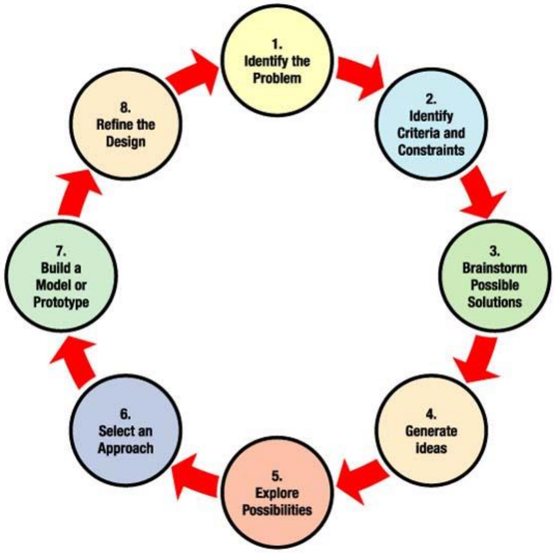
9-1. Redesign

- It is a cyclic process. Back to first step.



ME 122 Process

1. Identify the problem
2. Define product requirements and constraints
3. Literature review/ Brainstorm Ideas
4. Generate Ideas / Sketch and schematics
5. Explore Possibilities / Pros and Cons of each idea
6. Select an approach / Mockup
7. Model and Prototype / SolidWorks, Prototype iterations
8. Test and Refine
9. Present



Requirements Definition

- From NASA:
  - The following definitions differentiate between requirements and other statements.
    - Shall: This is the only verb used for the binding requirements.
    - Should/May: These verbs are used for stating non-mandatory goals.
    - Will: This verb is used for stating facts or declaration of purpose.

- For ME 122: (Group Assignment 2– minimum 4 requirements/constraints in each category)

  Automatic Door Widget Example:
  - Function
    - "The widget shall have the capability to unlock a standard (DEFINE) office door"
  - Performance
    - "The widget shall perform (TASK) within 30 +/- 5 seconds of receiving a command"
  - Interface
    - "The widget shall accept input from a human operator speaking five (5) distinct pre-defined voice commands".
  - Environment
    - "The widget shall function in an environment from 0-90 degrees Celsius"
    - "The widget shall be recoverable from an environment from 91-120 degrees Celsius"
  - Safety
    - "The widget shall have no surface exposed to human contact in excess of touch temperature (50 degrees Celsius)".

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Terms Related to Design and the Design Process

• Design Cycle:	Process of: design, build, test, break, redesign
• FOM	Figures of Merit (how do you measure the important stuff)
• KPP	Key Performance Parameters (design is filled with trades – you have to decide early on what is most important)
• Ops Con	Concept of Operations. The time line of everything. Who uses it, who touches it, who repairs it, where it goes, how it is used.
• Requirements	Engineering contractual language. Requirements are quantified and verified.
• Risk	Formally tracked issues that keep engineer up at night. Documented and tracked on “likelihood vs. consequence” tables.
• Hazards Analysis	Formal tracking of things that can go wrong. Designs with components that get hot can cause fires. Each hazard has a formal hazard control plan.

Terms Related to Design and the Design Process

• Interfaces:	Things the design connects: environments, humans, mechanical, electrical, fluid, structural
• PDR	Preliminary Design Review. Formal audit of documents that declares everybody knows system requirements, and the design team can sign up to ICD (Interface Control Document)
• CDR	Critical Design Review: The formal audit of the design, where the customer releases the money to build the thing.
• Breadboard	Early design iteration “thing” – no effort to package
• Brassboard	Middle design iteration “thing” – no effort to package, but uses components intended for final build
• Prototype	Middle design iteration “thing”
• EDU	Engineering Development Unit. A prototype that can be tested, and test results predict performance.
• Qualification Unit	Prototype that is controlled. Results can verify requirements are met

Terms Related to Design and the Design Process

• Qualification:	Proving the design meets the requirements
• Acceptance:	Proving that each item (by serial number) can be used.
• Stakeholders	The list of people involved. A deliberate list should be kept, and at each critical review – all stakeholders should formally accept, or write down their concern.
• P&ID	Process and Instrumentation Diagram. The engineering drawing of the components in a design, how they are configured, and where the instruments are located.
• Process Sheet	Similar to P&ID, a term used by chemical engineers. It is a map that tracks all mass flow, and tracks all energy flow.
• FMEA	Failure Modes and Effects Analysis. A way of tracking hazards.