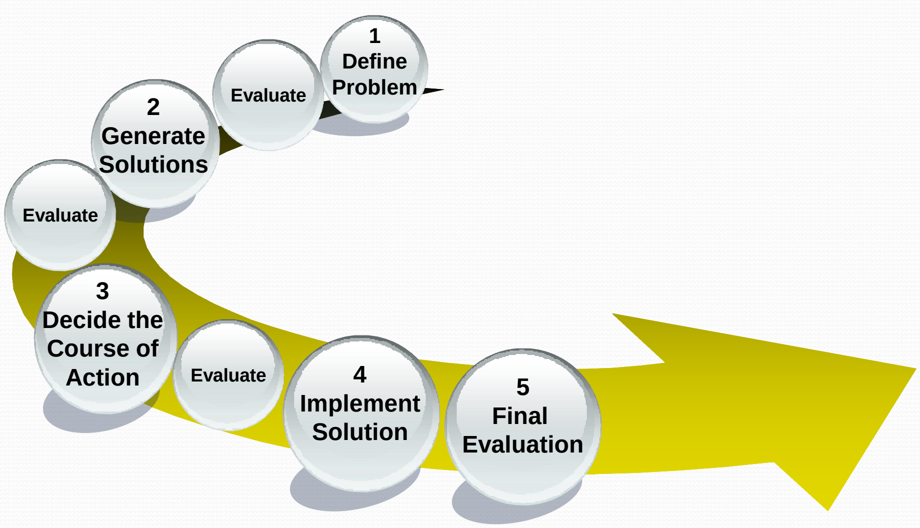
Engineering Design Process

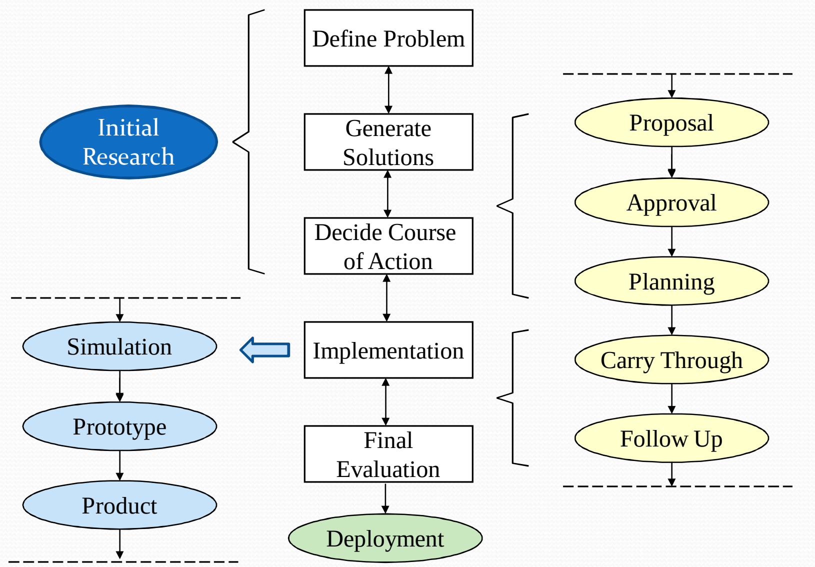
Prepared for CSE Capstone Course

Dr. Yinong Chen

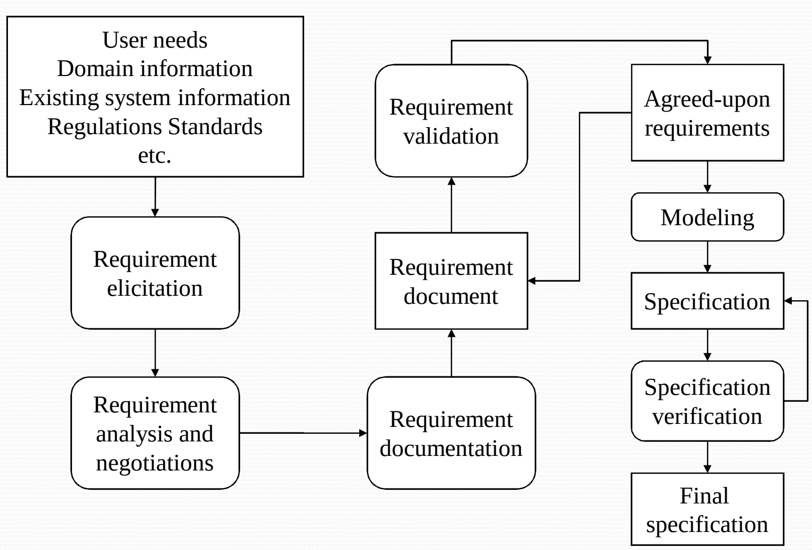
The Engineering Design Process



Overview



Problem Definition: Requirement & Specification Engineering



Engineering Models

- Conceptual Models: Based on description of concepts and relationships among model components
  - The five-component model of computer systems
  - Flowchart of your design or program
- Mathematical Models: Based on logical and quantitative relationships among model components
  - Deterministic Models: predictable behavior, always give same answer each time we run the model, for a fixed set of design parameters.
  - Stochastic Models: element of chance built into model different unpredictable answer each time we run the model even when design parameters are fixed only average behavior over several runs predictable
- Physical Models: Smaller versions of the full-size systems, e.g., a model car, airplane, etc.

Model Elements

- Problem Definition
- Boundaries: Pre-conditions or assumptions that are assumed to be true, e.g., the system will be operated in the temperature between 32 and 125 degree.
- Variables: The dimensions that impact the system behaviors.
- Range of values for each variable.
- Relationships or formulas/functions that link the variables together.
- Solution: Using the variables and relationship to specify the problem.

Generating Solutions: Brainstorming

- Brainstorming
  - Purpose:
    - To generate a high volume of ideas in a non-analytical manner
    - To permit the ideas of one individual to stimulate the ideas of the other individuals in a team.

Rules of Brainstorming

- **Objective:** To generate as many solution ideas as possible, regardless of feasibility
- All ideas are recorded without commentary or judgement
- Phrases that are **not** to be said during brainstorming:
  - *That won't work*
  - *That's too radical*
  - *It's not our job*
    - *We don't have enough time*
    - *That's too much hassle*
    - *That's too expensive*
    - *That's a stupid idea*
    - *We can't possibly do that*
    - *You are an idiot*

Generating Solutions: Osborn's Checklist

- **<u>Objective:</u>** To build upon ideas generated from brainstorming, yielding new ideas
- The Checklist:
  - Adapt?…
    - What are other uses for this product/idea/plan?
  - Modify?…
    - Can we change the shape, material, color, smell?
  - Magnify?…
    - How can we make this item longer, bigger, faster?
  - Minify?…
    - How can we make this item smaller, lighter, shorter?
  - Substitute?…
    - Use different ingredients, material, people?
  - Rearrange?
    - Other layouts? Parts? Turn upside down, backwards?
  - Combine?
    - Parts? Units? Ideas? People?

Deciding the Course of Action

- In the engineering process, decisions must be made using measurable (quantitative) criteria;
- Design the criteria based on careful studies of the requirements and specification;
- A common tool used is:

  Kepner-Tregoe (K.T.) Decision Analysis; also, called KTDA

KT Decision Analysis

1. Create a short list of 3-5 design ideas/solutions
2. Clearly define the design objectives and measurable criteria;
3. Categorized them into:
   - **MUSTS:** Those objectives/criteria that are required to be met contractually or that must be met for the design to properly function
   - **WANTS:** Those objectives/criteria that would be good for the design to have, but that are not essential contractually or functionally

KTDA Example - A Race Robot

		Decision Analysis					
Alternative:		Robot A		Robot B		Robot C	
Musts	1. < 20 lb 2. < $400	GO GO		GO GO		NO GO GO	
Wants	Weight	Rating	Score	Rating	Score	Rating	Score
1. cost	4	7	28	3	12	X	
2. speed	7	4	28	7	49		
		Total A = 56		*Total B = 61*		*Total C =*	

Solution B looks like the solution of choice

Example: National Institute of Standards and Technology 10-Step Enterprise Planning Process

http://www.nist.gov/director/vcat/planning_0606.pdf