Engineering Design Process

Lecture 1
Spring 2018
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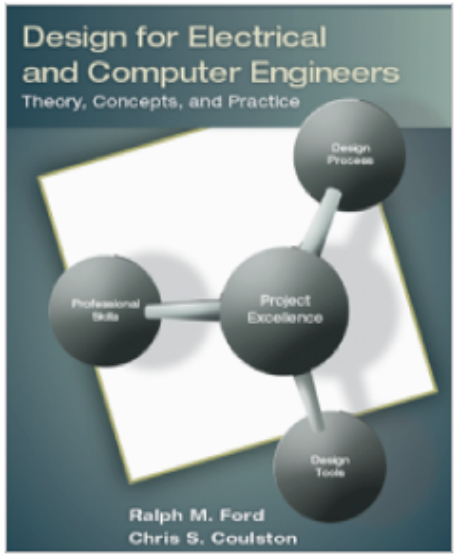
Slides adopted from R. Gutierrez

Plan

- **Engineering science vs. design**
- **What is an engineer?**
- **Engineering design**
- **Elements of the design process**



Engineering science vs. design

- **Engineering science problems**
  - Problem statement is compact and well-posed
  - Problem uses specialized knowledge
  - Problem has a readily identifiable closure
  - Solution is unique and compact

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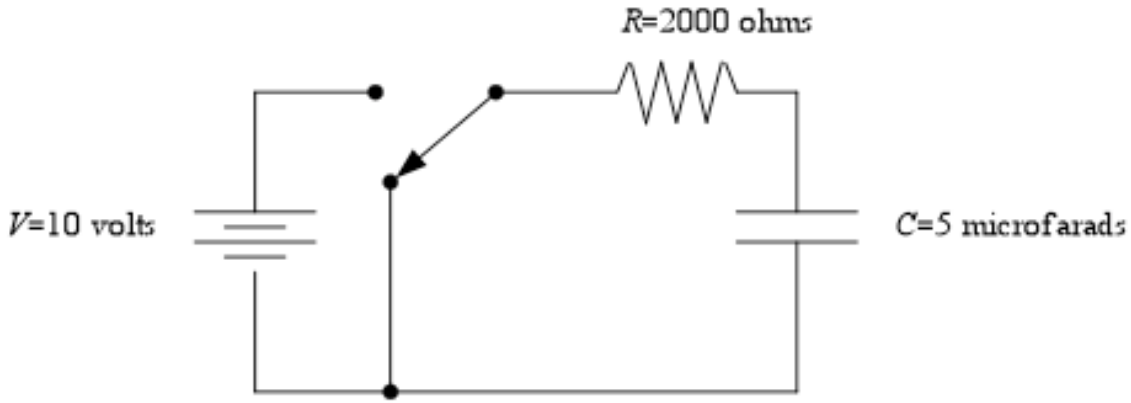

How much current is flowing through the circuit 0.1 sec after the switch is closed?

- **Engineering design problems**

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Design a system for lifting and moving loads of up to 5000 lb in a manufacturing facility. The facility has an unobstructed span of 50 ft. The lifting system should be inexpensive and satisfy all relevant safety standards.

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–American College Dictionary

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- Methodical application of scientific knowledge and technology
  - In contrast with other design/creative endeavors, e.g., creative writing
- Innovative vs. methodical
  - Both terms are in competition
  - A good engineer is aware of this and uses both effectively
- Satisfy human needs
  - You must determine the user's needs and apply technology ethically

What is engineering design?

Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation. [ABET]

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- The design process
  - Problem-solving methodologies that aim to develop a system that best meets the customer's needs within given constraints
- Iterative
  - In recognition that early in the process you don't know all the answers (or sometimes even the questions)
- Meeting an objective
  - There is always one (or multiple) –engineering design is not aimless

Types of design processes

Prescriptive

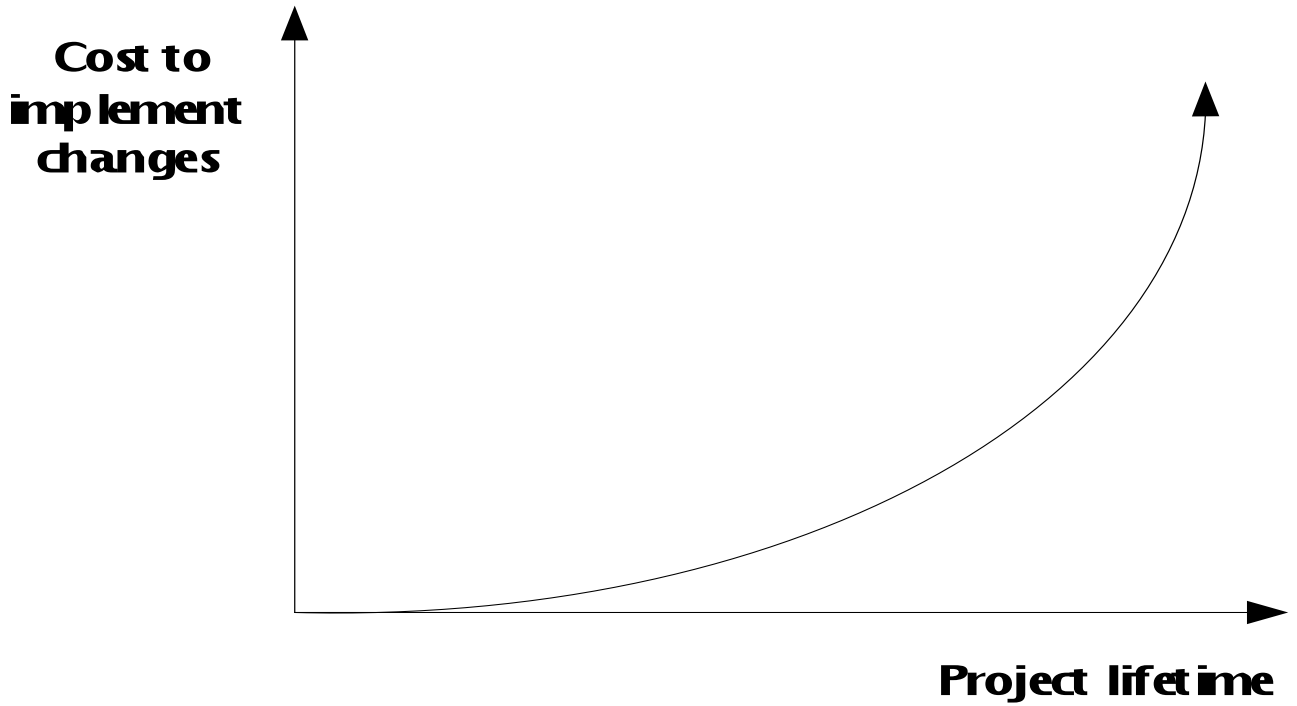
- They set down an exact process or recipe for realizing a system
- Often algorithmic and expressed on flow charts with decision logic

Descriptive

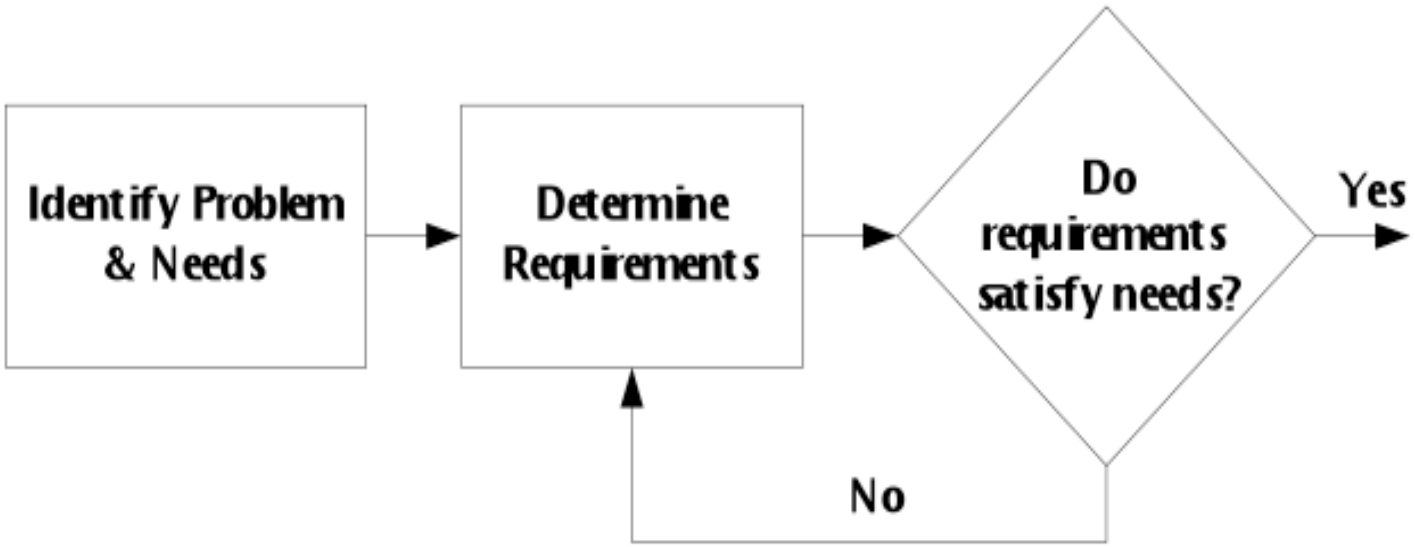
- Describe typical activities involved in realizing designs
- Less formal, less emphasis on exact sequencing

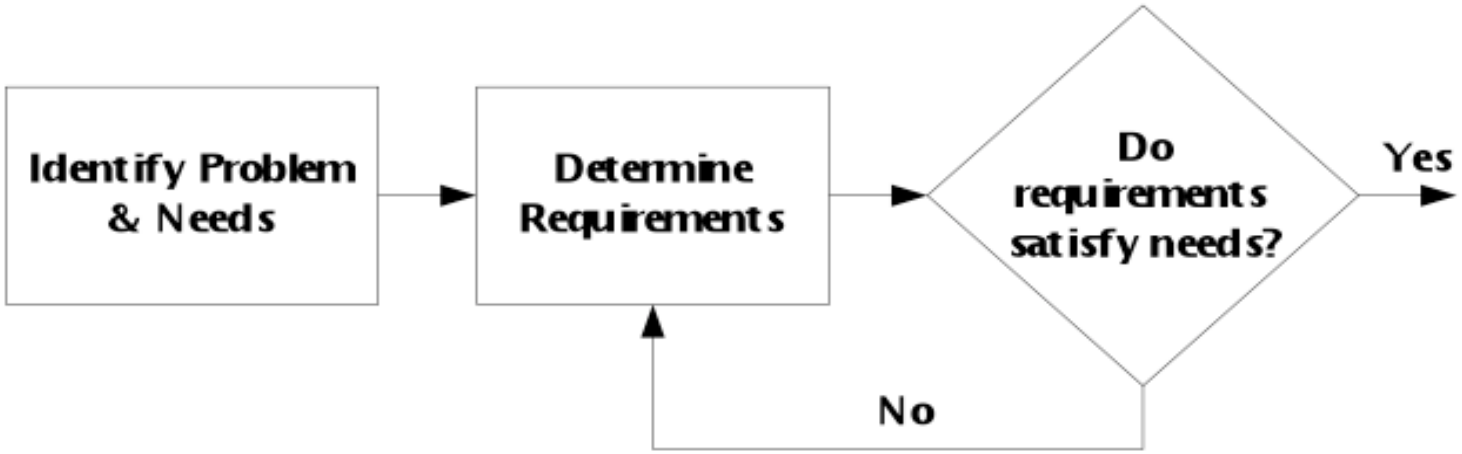
Why follow a design process?

- It formalizes thought processes to ensure good practices are followed, which leads to better and more innovative solutions
- It keeps all members of the team synchronized in terms of understanding where they are in the process



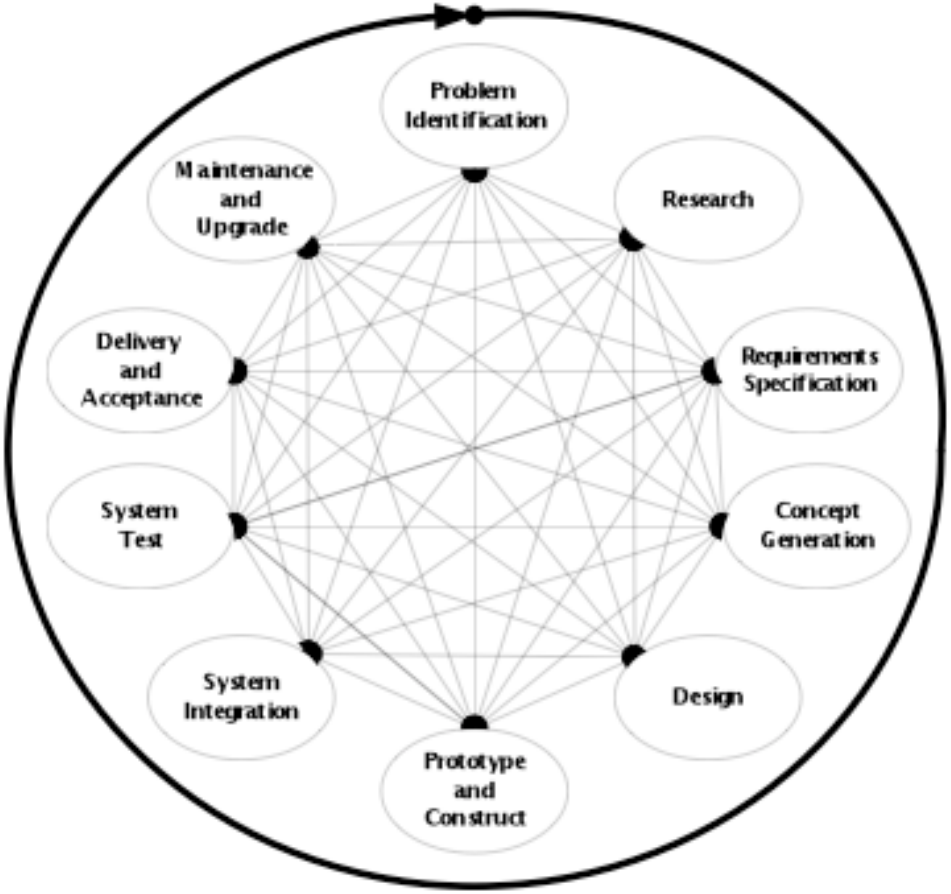
A prescriptive design process



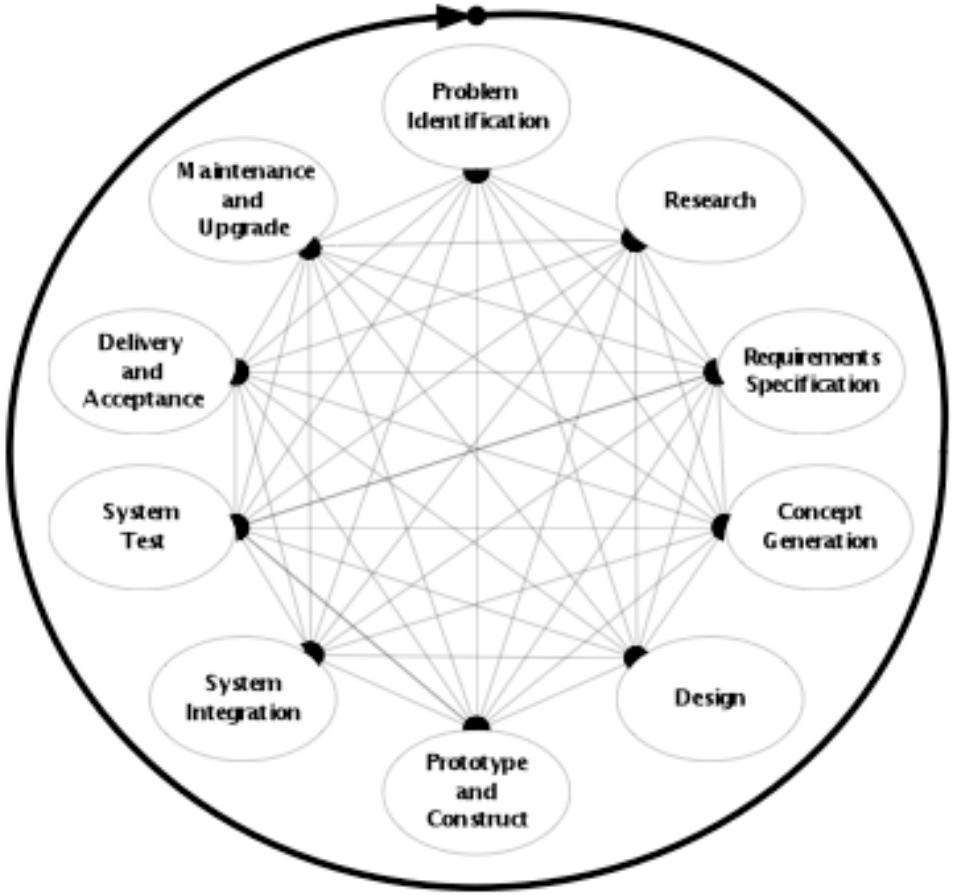


– This model is unrealistic, and ignores the iterative nature of design, where the team alternates between different phases as needed

A descriptive design process



A descriptive design process



- Allows transitions between the different phases
- The engineer may alternate between nearby phases
  - e.g., between problem ID, research, requirements specs, concept generation
- However, transitions between remote phases can be costly
  - e.g., the customer needs may change, which requires reevaluation of needs, requirements specifications

Elements of the design process

[1] Problem identification

- What is the problem being solved or the customer need to be met?
- Could result from someone conceiving a new idea or from a client approaching you with a need

[2] Research

- Immersion in basic engineering, scientific principles and technologies
- You must become a domain expert to avoid reinventing the wheel

[3] Requirements specification

- Articulates what the system must do for it to be successful and be accepted by the customer
- Very challenging for engineers since we are trained to solve problems instead of specifying them

[4] Concept generation

- The design is open-ended, so you must generate multiple solutions
- Alternates creative thought and critical evaluation (not simultaneously)

[5] Design

- Iteratively develop a technical solution, leading to a detailed design
- Upon completion, all major systems and subsystems are identified and described using an appropriate model (e.g., functional, behavior)

[6] Prototyping/construction

- Different elements of the system are constructed and tested
- In prototyping, the goal is to experiment, establish proof-of-concept, and improve understanding

[7] System integration

- All the subsystems are brought together to produce a working system
- Requires clear communication of functionality and interfaces during the design phase

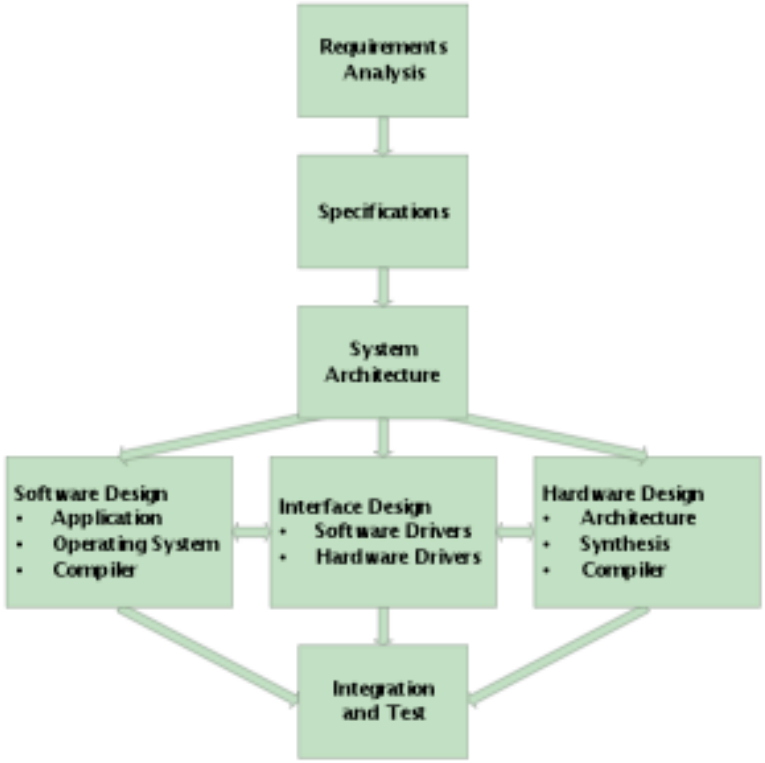
[8] Testing

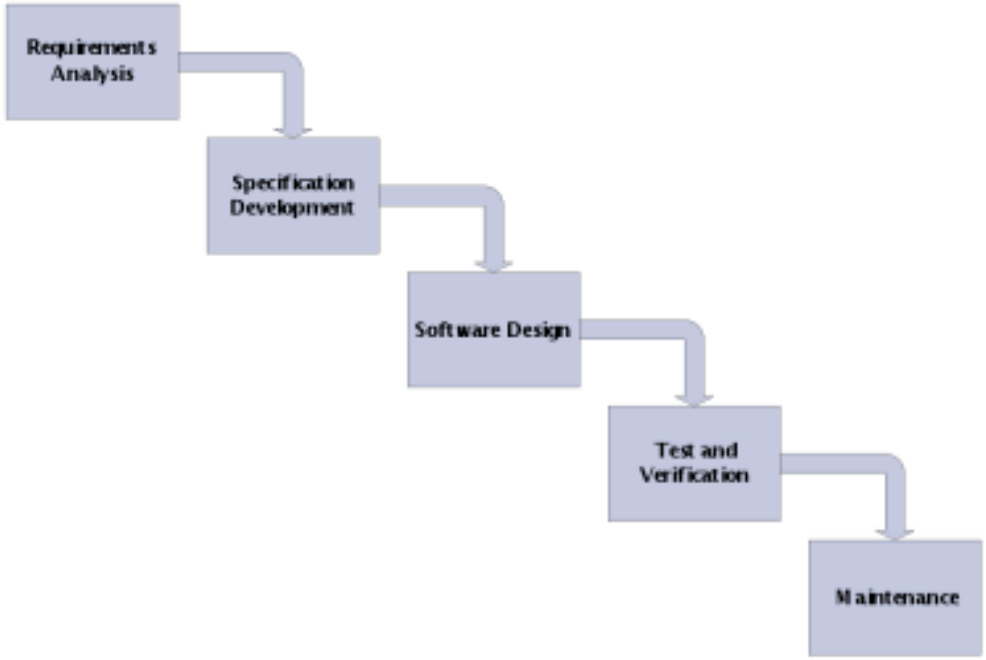
- Unit tests, regression test, integration test, acceptance test
- The final objective is to demonstrate that the overall system meets the client's needs

[9] Maintenance

- After deployment: maintain, upgrade, add new functionality, correct design problems

Technology-specific design processes

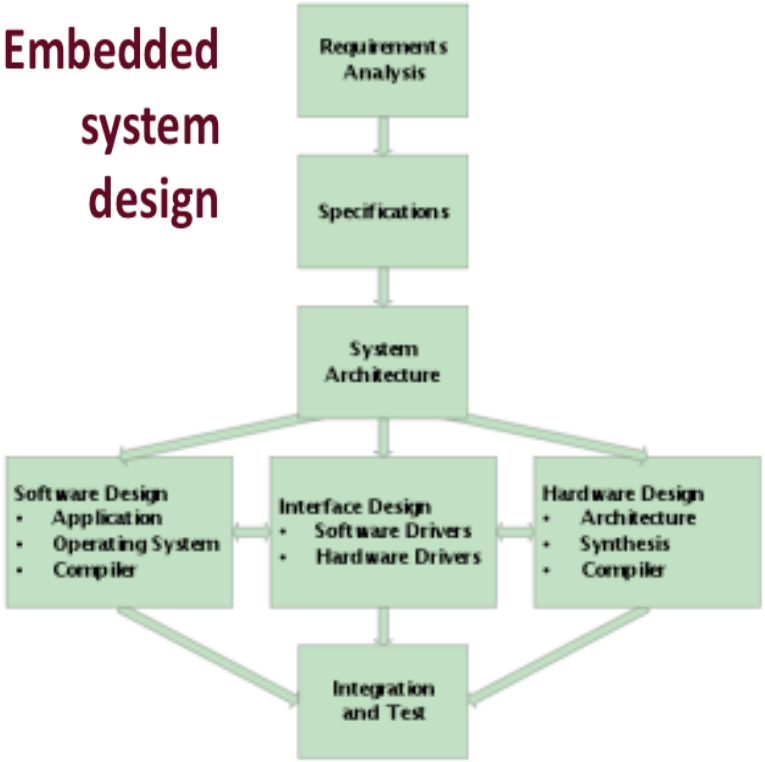




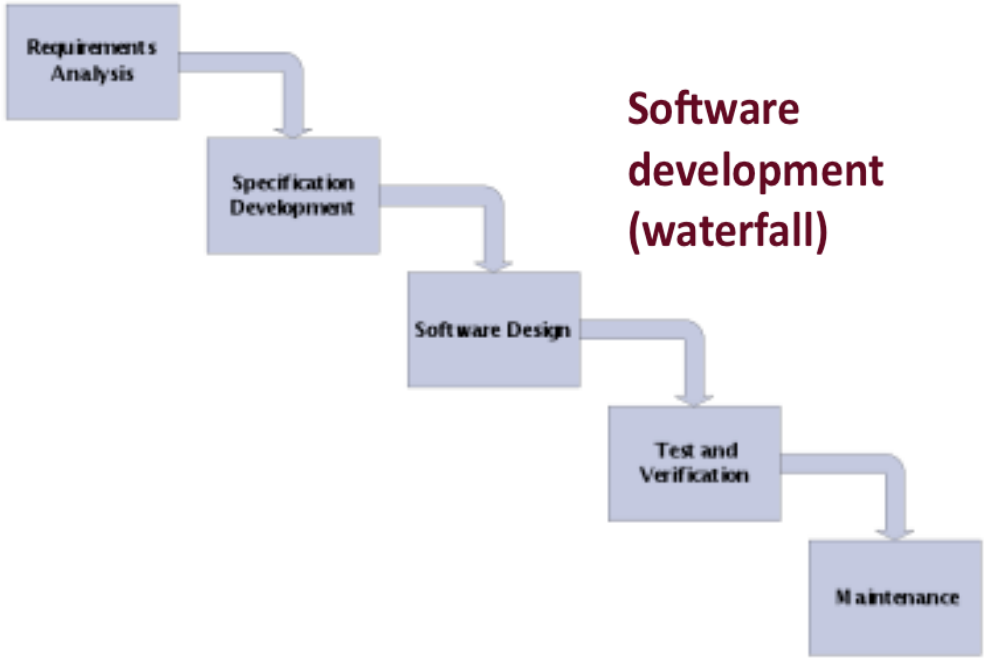
Technology-specific design processes

VLSI Design

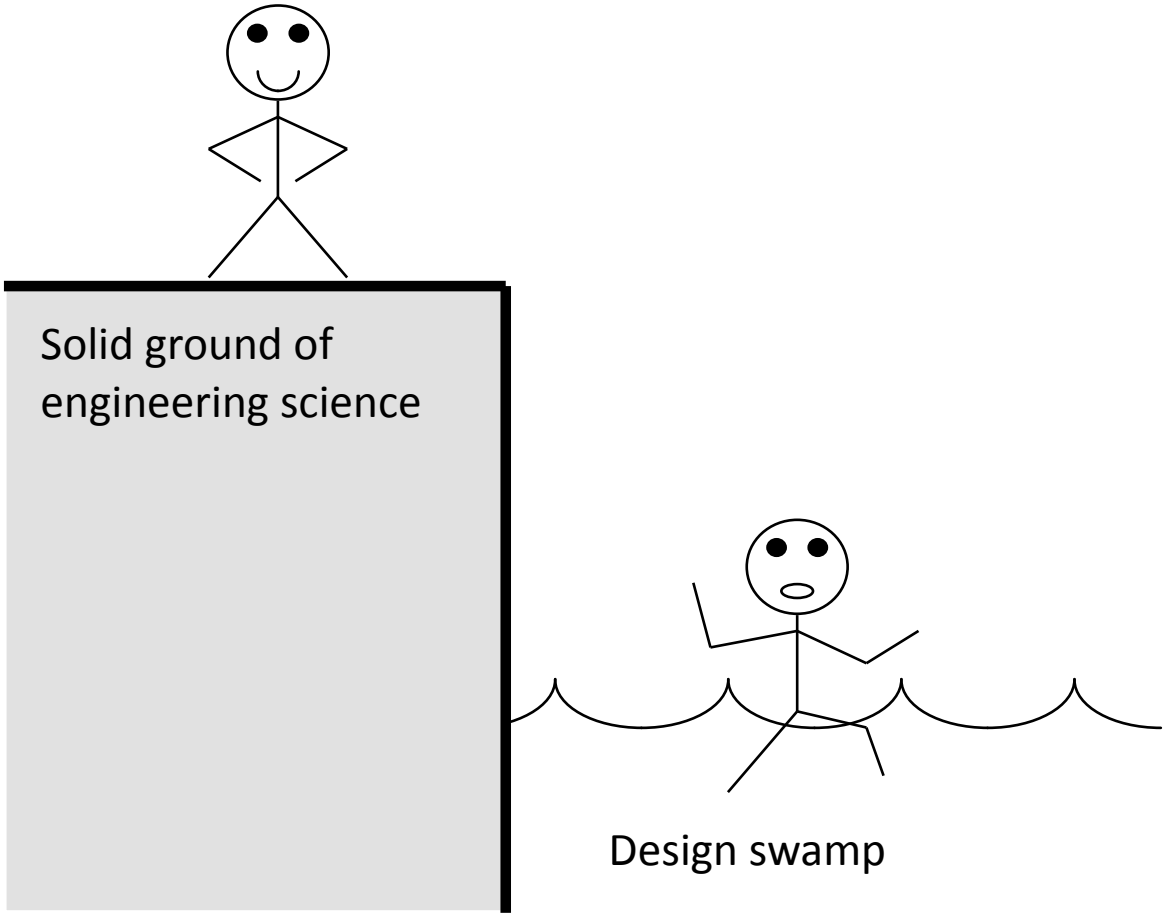
Embedded system design

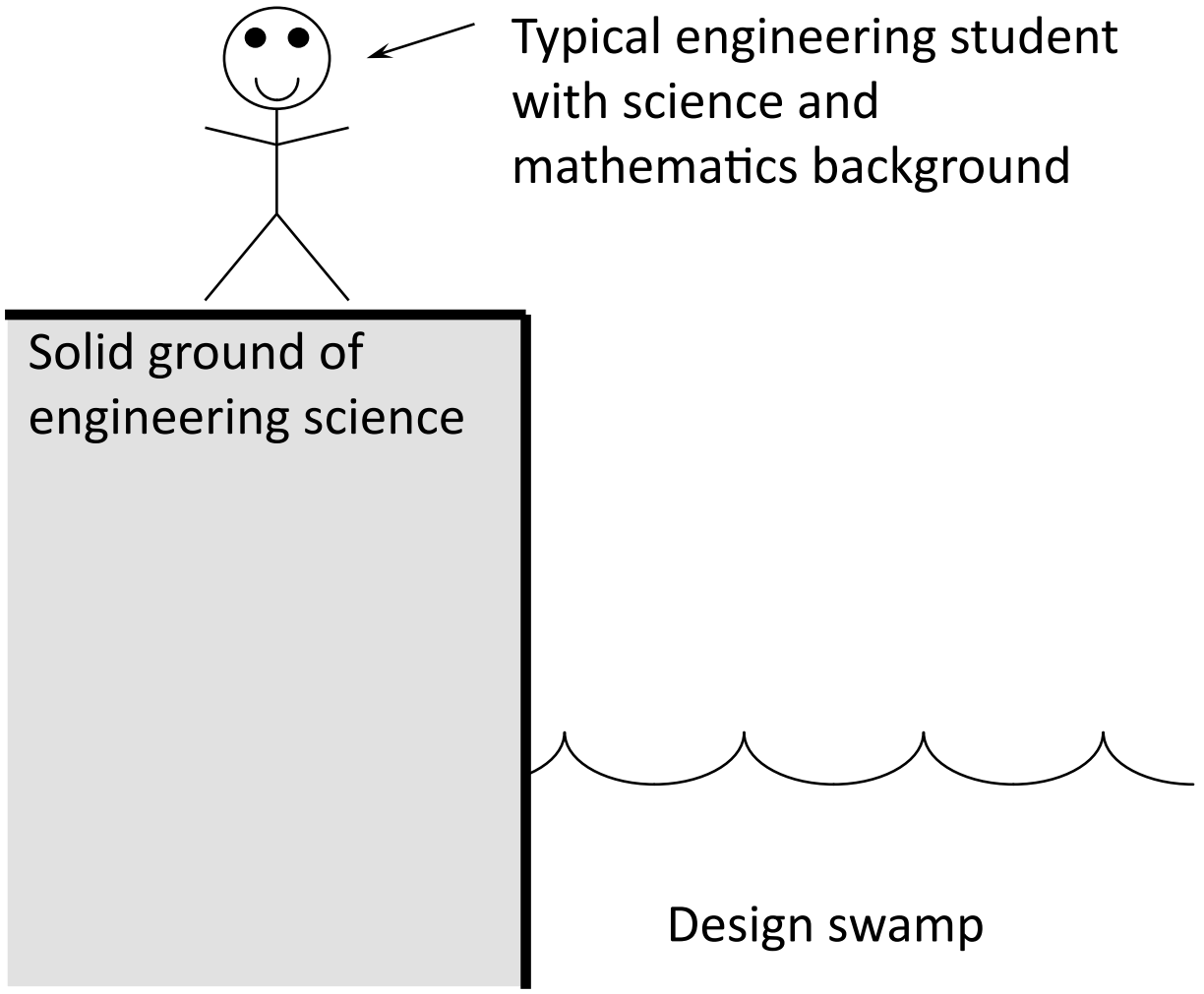


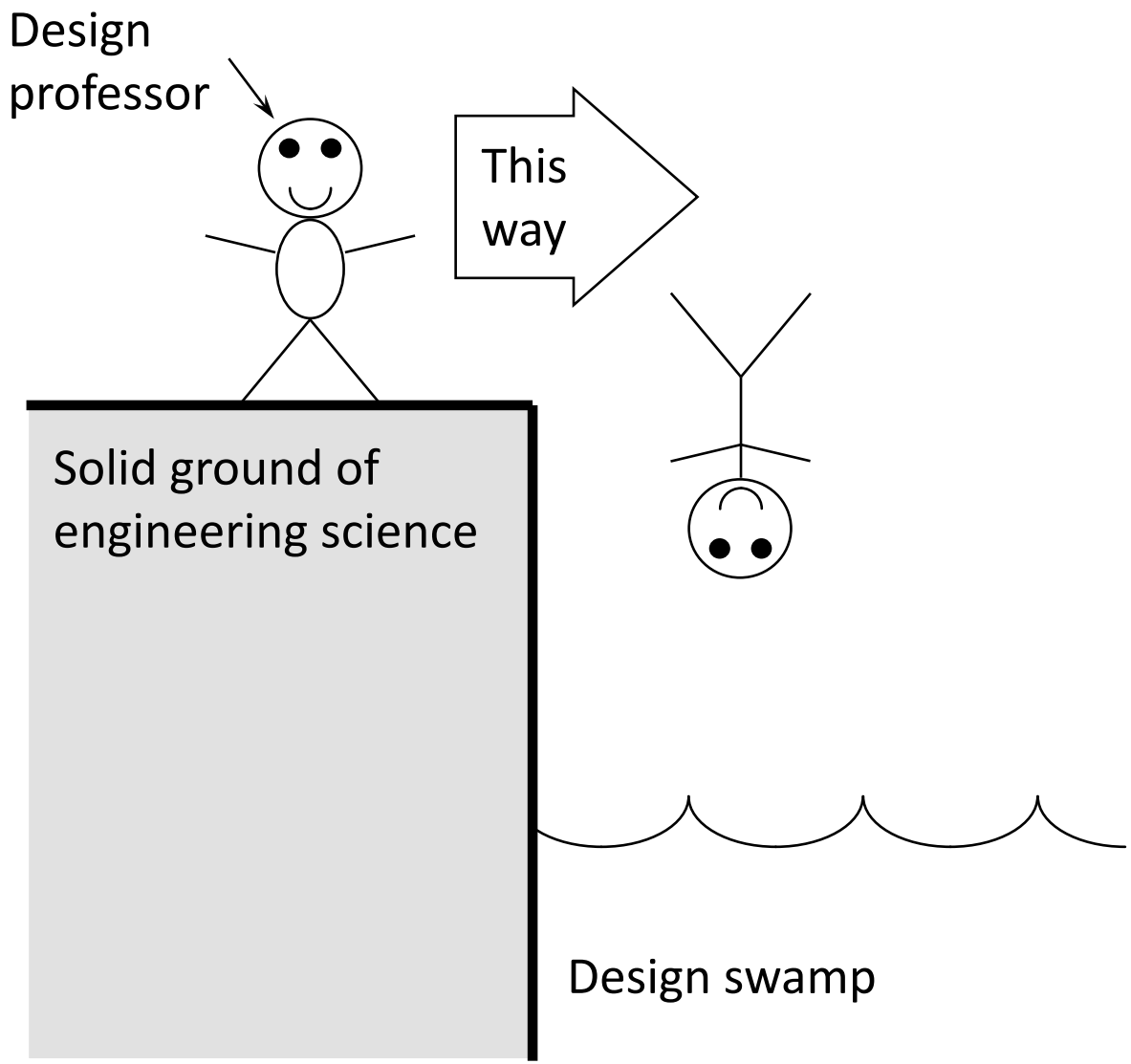
Software development (waterfall)

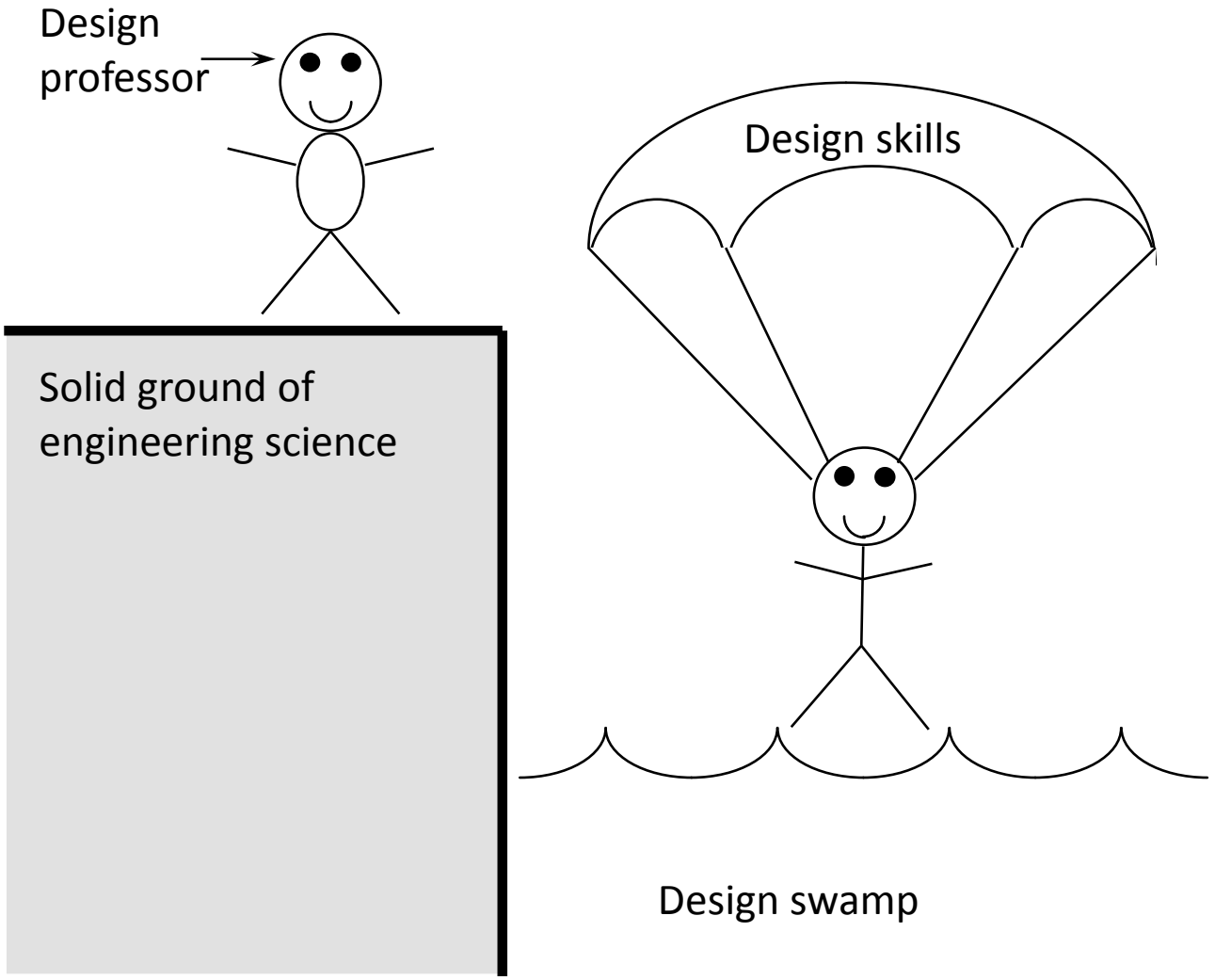


Topography of engineering science and design




Typical engineering student with science and mathematics background
Solid ground of engineering science
Design swamp


Design
professor
This
way
Solid ground of
engineering science
Design swamp


Design
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Solid ground of
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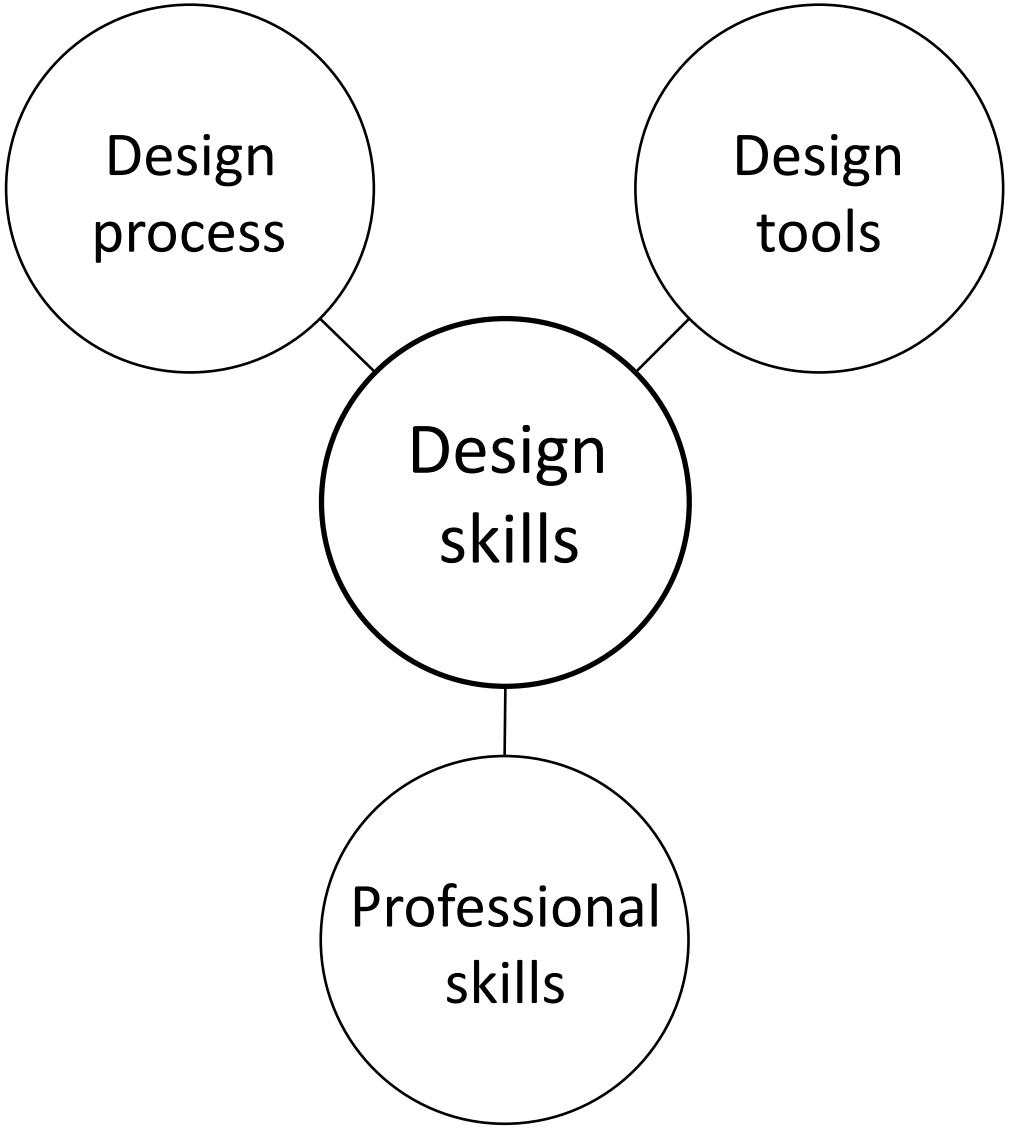
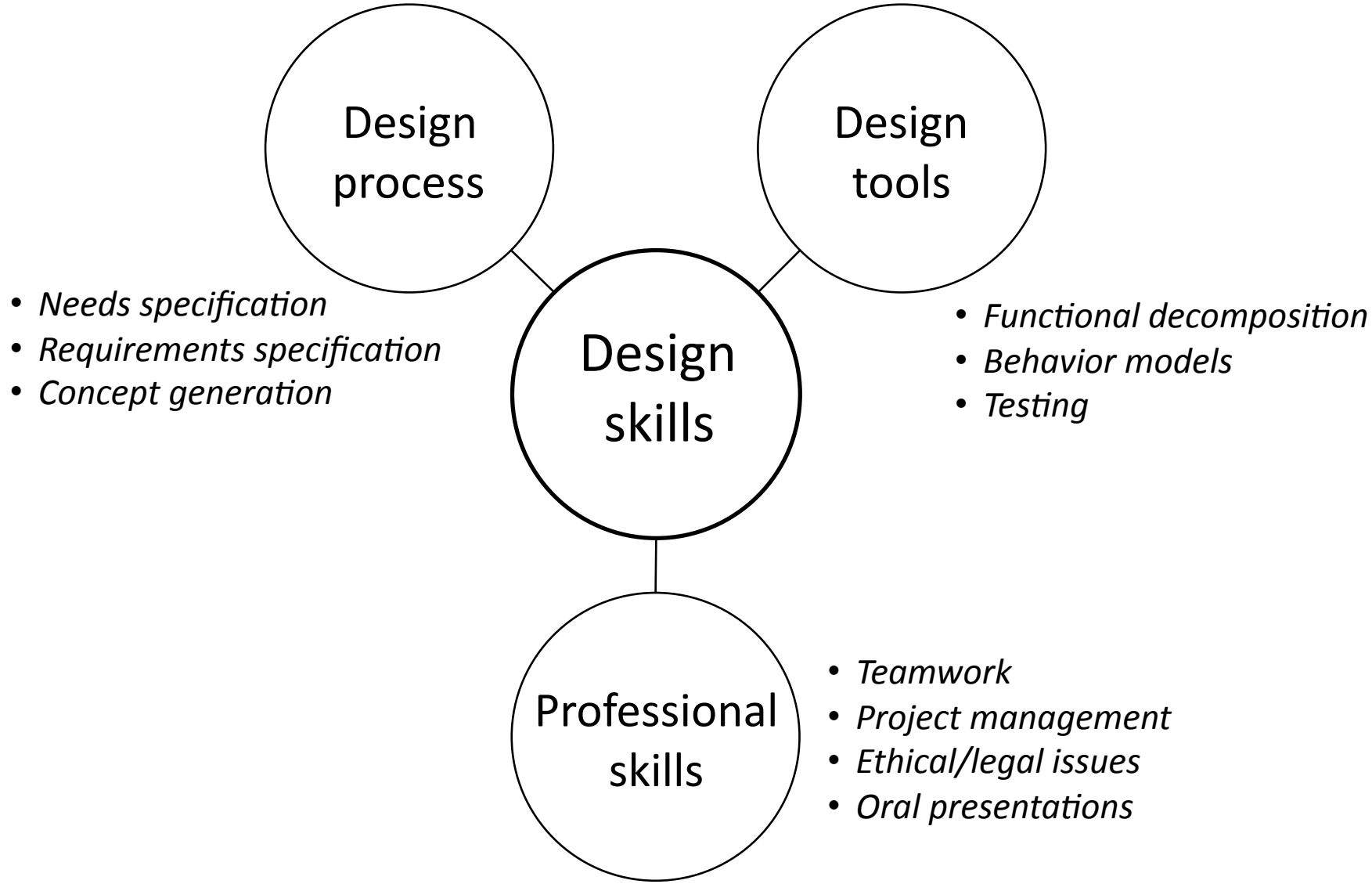
Design skills
Design swamp

Course objectives




Design process
Design tools
Design skills
Professional skills
• Needs specification
• Requirements specification
• Concept generation
• Functional decomposition
• Behavior models
• Testing
• Teamwork
• Project management
• Ethical/legal issues
• Oral presentations

Lecture summary

- Design problems are open-ended with many potential solutions
- Design processes represent best practices for realizing a system
- Engineering design is an iterative process
- Design processes may be prescriptive or descriptive