ELE 491
Senior Design Project Proposal

These slides are loosely based on the book Design for Electrical and Computer Engineers by Ford and Coulston. I have used the sources referenced in the book freely and without re-attribution. Please see the book for full source attribution

ELE 491
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Class 2 – Engineering Design Process

Design Process
ABET
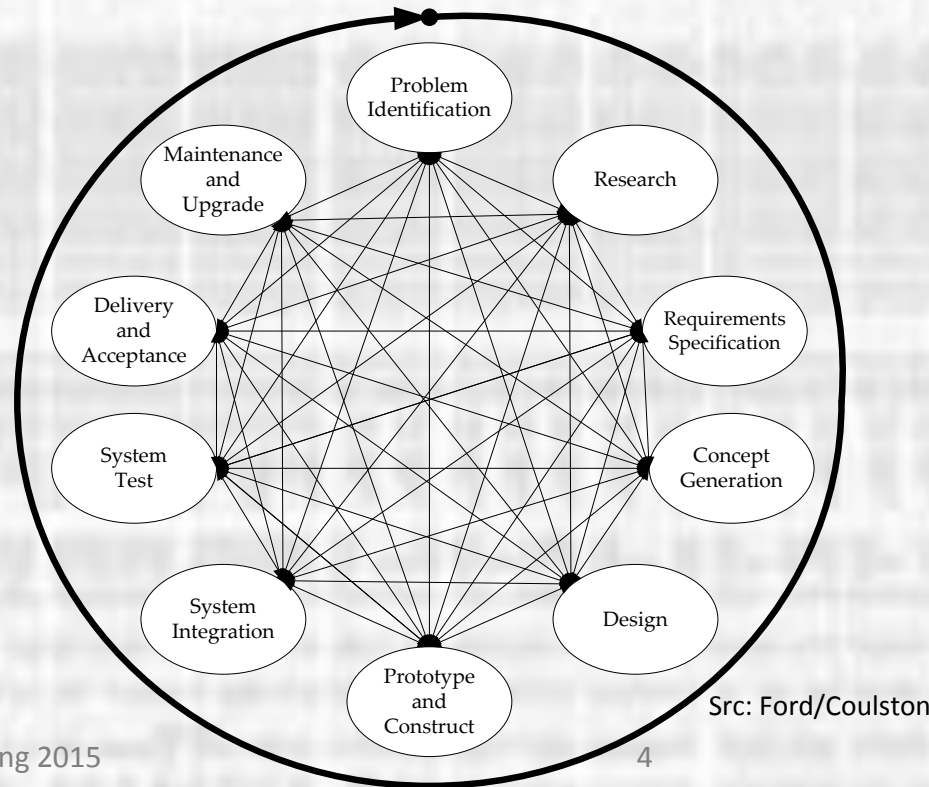
- ABET – Accreditation Board of Engineering and Technology

  - 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.
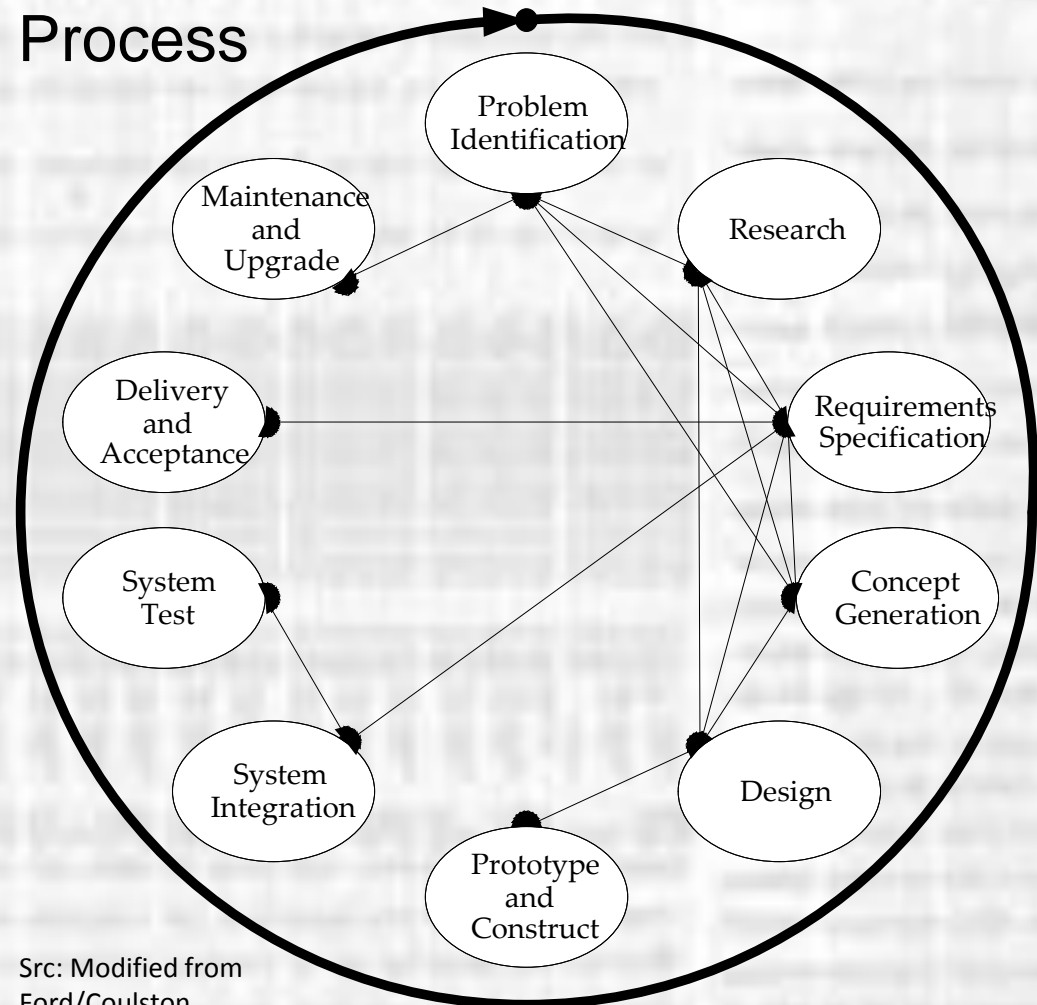
Design Process
Overview

- **Descriptive Design Process**
  - Each element informs and feeds back to every other element
  - Must constantly ask: "how does the decision I am about to make impact my prior assumptions and future decisions".

Src: Ford/Coulston

Design Process
Overview

- Descriptive Design Process

  - Common loops

Problem Identification

Maintenance and Upgrade

Research

Delivery and Acceptance

Requirements Specification

System Test

Concept Generation

System Integration

Design

Prototype and Construct

Src: Modified from Ford/Coulston

Design Process
Descriptive Design Process

- Problem Identification

  - In most cases you will be given the problem to solve

  - It is critical to test this problem identification

    - Do you understand the problem

    - Is it the fundamental problem or an already half solved problem

    - Is it well defined, but not over defined

Design Process
Descriptive Design Process

- Research

  - Understand the underlying principles of the problem

  - Review current solutions

    - Look for gaps and opportunities to innovate

  - Become a subject matter expert

Design Process
Descriptive Design Process

- Requirements Specification

  - Identify what the system must do to solve the problem

    - Over specify:
      - Higher cost
      - Longer development time

    - Under specify
      - Don't solve problem
      - Customer does not accept the solution

  - No design solutions should be assumed at this stage

    - Maximize the design space

Design Process
Descriptive Design Process

- Concept Generation

  - Multiple design solutions are conceived

    - Initially these can be wildly creative

  - Each design solution is explored far enough to allow it to be compared to:

    - Requirements

    - Other possible design solutions

  - Typically only one design solution emerges from this phase

Design Process
Descriptive Design Process

- Design

  - Hierarchical system design

  - Up/Down sub-system design

  - Detailed block, module, circuit, and software design

  - Heavy reliance on models and simulation tools

  - Tight feedback with prototyping phase

Design Process
Descriptive Design Process

- Prototyping and Construction

  - Used to inform the design process

  - Prototype small elements of the design in very tight loops

  - Prototype larger elements of the design at critical development points

  - For long lead time elements (e.g. Integrated Circuits) it is critical to make the right decisions on prototyping
    - More design time → less time to correct errors found in prototyping
    - Early prototyping → more errors → higher chance of errors in the fixes

Design Process
Descriptive Design Process

- System Integration

  - Pull everything together

    - Happens at multiple levels of the design hierarchy

  - Highlights specification errors (between sub-systems)

  - Highlights communications errors (between teams)

Design Process
Descriptive Design Process

- ## System Test

  - ## Test everything together

    - ## Happens at multiple levels of the design hierarchy

  - ## Validates the system to the original Requirements Specifications

    ## → does it solve the original problem

Design Process
Descriptive Design Process

- Delivery and Acceptance

  - In situ testing

    - Validate the solution

    - Uncover unexpected interdependencies

    - Frequently require "tweeks" to the solution or the system

Design Process
Descriptive Design Process

- ## Manufacturing

  - ### Determine manufacturability

    - #### Component robustness

    - #### Overall system yield

    - #### Complexity

Design Process
Descriptive Design Process

- Maintenance

  - Resolve ongoing design issues

  - Add functionality over time

  - Manage defects

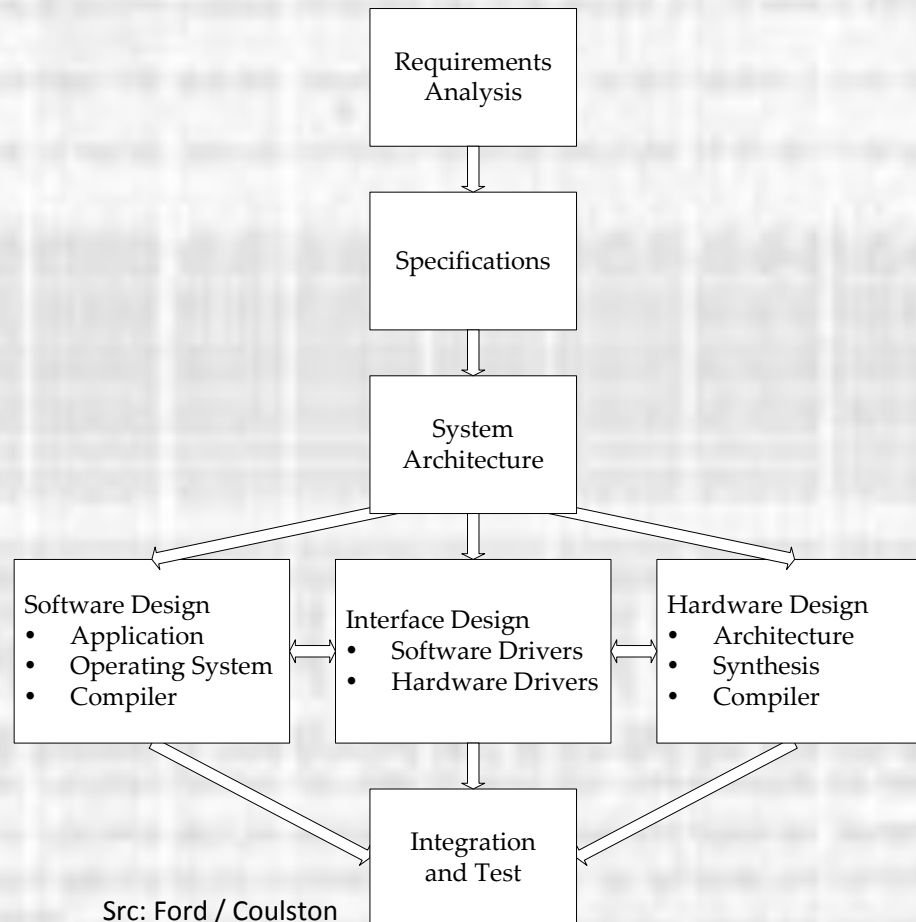# Design Process
Examples

- IC Design

| Specification | → | System Architecture | → | Logic Design | → | Circuit Design | → | Layout |

Src: Ford / Coulston

Design Process
Examples

- Embedded System Design

```
        ┌─────────────────┐
        │  Requirements   │
        │    Analysis     │
        └─────────────────┘
                 │
                 ▼
        ┌─────────────────┐
        │ Specifications  │
        └─────────────────┘
                 │
                 ▼
        ┌─────────────────┐
        │     System      │
        │  Architecture   │
        └─────────────────┘
```

Software Design	Interface Design	Hardware Design
• Application	• Software Drivers	• Architecture
• Operating System	• Hardware Drivers	• Synthesis
• Compiler		• Compiler

```
        ┌─────────────────┐
        │  Integration    │
        │   and Test      │
        └─────────────────┘
```

Src: Ford / Coulston

Design Process
Examples

- ## Software Development

Requirements Analysis → Specification Development → Software Design → Test and Verification → Maintenance
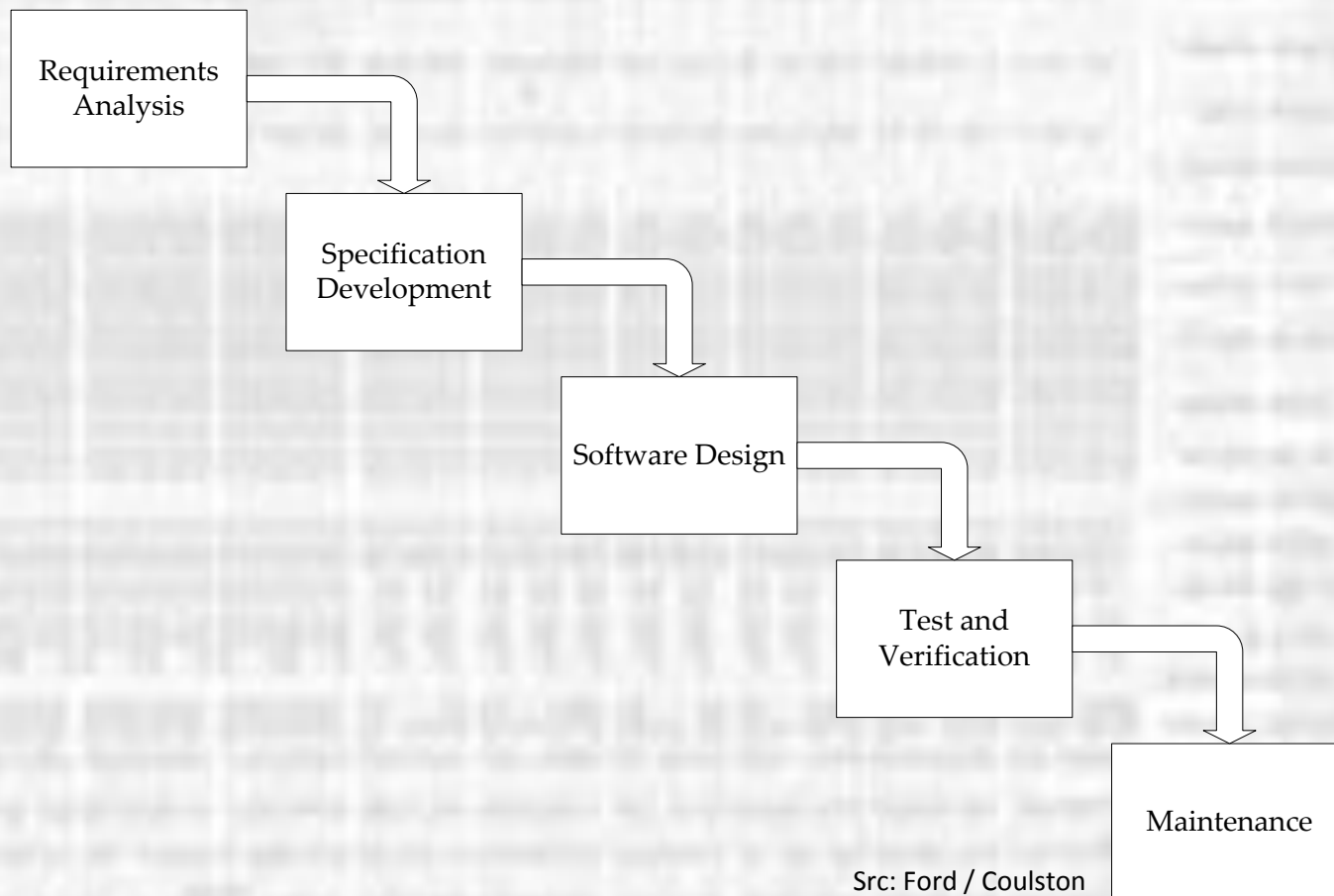
Src: Ford / Coulston

Design Process
Overview

- Project Flow

  - Identify problems
  - Create requirements
  - Generate/evaluate conceptual solutions
  - Decomposition
  - Modeling and Design
  - Validation
  - Delivery

In Class Activity