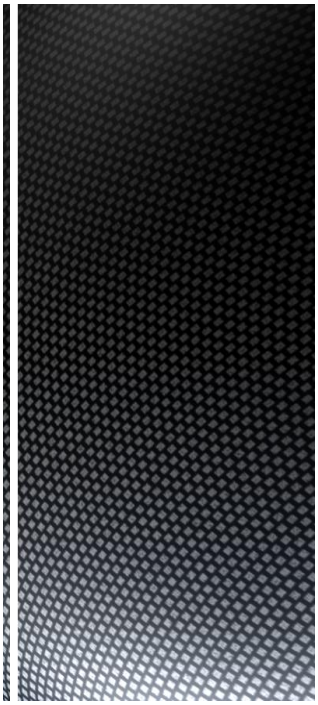


Product Planning & Development (21-423)

Advanced Manufacturing Laboratory
Department of Industrial Engineering
Sharif University of Technology

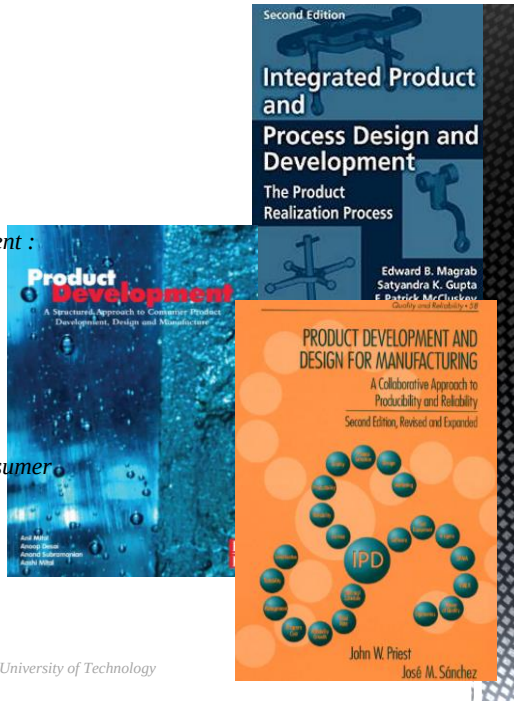
Session #15

Course Description

- *Instructor*
  - *Omid Fatahi Valilai, Ph.D. Industrial Engineering Department, Sharif University of Technology*
  - *Email: FValilai@sharif.edu , Tel: 6616-5706*
  - *Website: Sharif.edu/~fvalilai*
- *Recommended prerequisite*
  - *Manufacturing process I (21-418)*
- *Class time*
  - *Sunday-Tuesday 18:00-19:30*
- *Course evaluation*
  - *Mid-term (25%)*
  - *Final exam (40%)*
  - *Quiz (5%)*
  - *Exercise (Manufacturing Lab.) (30%)*

Session reference

- *Reference:*
  - *Edward B., "Integrated product and process design and development : the product realization process", CRC Press, 2010*
  - *John Priest, Jose Sanchez; "Product Development and Design for Manufacturing: A Collaborative Approach to Producibility and Reliability, Second Edition", CRC Press, 2001*
  - *Mital et al. , "Product Development A Structured Approach to Consumer Product Development, Design, and Manufacture", Butterworth-Heinemann, 2008*

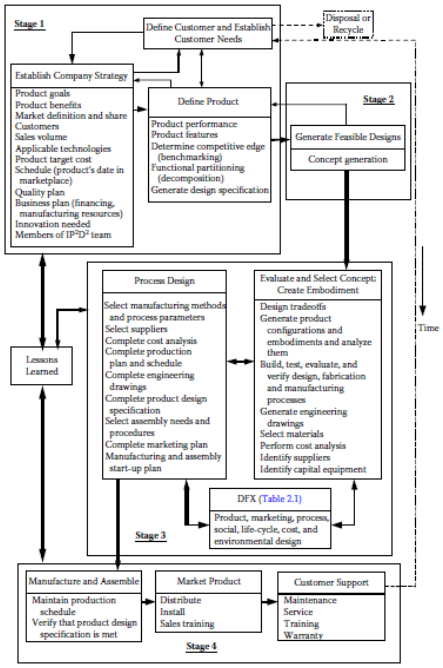


Course Description (Continued..)

- ***Contents:***
- *Product development in the changing Global world*
- *Stages of Product Development*
- *The Structure of the Product Design Process*
- *Early design: Requirement definition and conceptual Design*
- *Trade-off analyses: Optimization using cost and utility Metrics*
- *Detailed design: Analysis and Modeling*
- *Design Review: Designing to Ensure Quality*
- *Production System; Strategies, planning, and methodologies*
- *Production System Development*
- *Planning and Preparation for Efficient Development*
- *Supply chain: Logistics, packaging, supply chain, and the environment*

Detailed design: Analysis and Modeling

- *Detailed Design:*



Detailed design: Analysis and Modeling

- *Detailed Design analysis:*
  - *FMEA*
    - *Murphy's Law is that "If something can go wrong, it will".*
    - *Product failures and manufacturing problems will occur so we must*
      - *minimize their number,*
      - *minimize their effect, and*
      - *be ready for them when they occur.*
    - *Product failures affect reliability, safety, manufacturing, product liability, logistics, and most important customer satisfaction*

Detailed design: Analysis and Modeling

- *Detailed Design analysis:*
  - *FMEA*
    - *A failure mode and effects analysis (FMEA) is a technique for evaluating and reducing the effects caused by potential failure modes.*
    - *The design FMEA is a design analysis technique that documents the failure modes of each part, signal, or software module and determines the effect of the failure mode on the product.*
    - *The manufacturing process FMEA (PFMEA) focuses on the processes and vendor's failure modes.*
    - *For design, critical failure modes are eliminated through design improvements that can include component vendor selection, redundant circuit or software paths, alternative modes of signal processing, and design for safety.*

Detailed design: Analysis and Modeling

- *Detailed Design analysis:*
  - *FMEA*
    - *A failure mode and effects analysis (FMEA) is a technique for evaluating and reducing the effects caused by potential failure modes.*
    - *The design FMEA is a design analysis technique that documents the failure modes of each part, signal, or software module and determines the effect of the failure mode on the product.*
    - *The manufacturing process FMEA (PFMEA) focuses on the processes and vendor's failure modes.*
    - *For manufacturing, design improvements can include new processes, preventative maintenance, mistake proofing, operator training, etc*

Detailed design: Analysis and Modeling

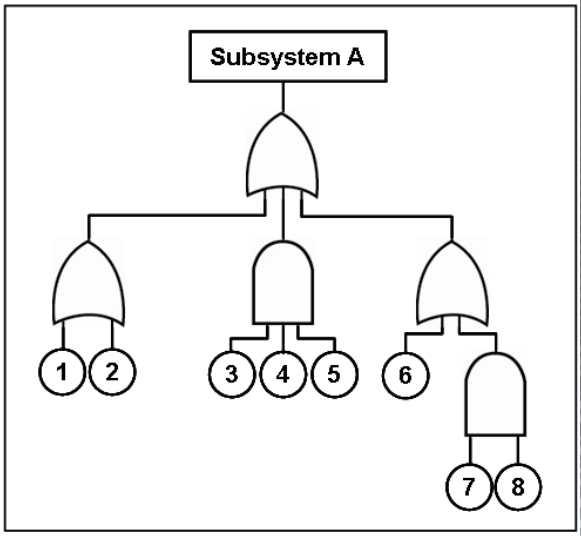
- *Detailed Design analysis:*
  - *FMEA*
    - *The analysis is a "bottom-up" approach.*
    - *Knowledge of the failure modes of each item or process is then used to determine the effect of each failure mode on system performance.*
    - *The key benefits to be derived from a FMEA are:*
      - *Identification of single-point failures*
      - *Early identification of problems and their severity*
      - *Information for design trade-off studies*

Detailed design: Analysis and Modeling

- *Detailed Design analysis:*
  - *FMEA*
    - *An FMEA is often the first step of a system reliability study*
    - *It involves reviewing as many components, assemblies, and subsystems as possible to identify failure modes, and their causes and effects.*
    - *For each component, the failure modes and their resulting effects on the rest of the system are recorded in a specific FMEA worksheet.*
    - *A successful FMEA activity helps to identify potential failure modes based on experience with similar products and processes - or based on common physics of failure logic.*

Detailed design: Analysis and Modeling

- *Detailed Design analysis:*
  - *FMEA*
    - *The analysis may be performed at the functional level until the design has matured sufficiently to identify specific hardware that will perform the functions; then the analysis should be extended to the hardware level.*



FMEA Ref.	*Item*	*Potential failure mode*	*Potential cause(s) / mechanism*	*Mission Phase*	*Local effects of failure*	*Next higher level effect*	*System Level End Effect*	*(P) Probability (estimate)*	*(S) Severity*	*Detection (Indications to Operator, Maintainer)*	*(D) Detection Dormancy Period*	*Risk Level P*S (+D)*	*Actions for further Investigation / evidence*	*Mitigation / Requirements*
1.1.1.1	*Brake Manifold Ref. Designator 2b, channel A, O-ring*	*Internal Leakage from Channel A to B*	*a) O-ring Compression Set (Creep) failure b) surface damage during assembly*	*Landing*	*Decreased pressure to main brake hose*	*No Left Wheel Braking*	*Severely Reduced Aircraft deceleration on ground and side drift. Partial loss of runway position control. Risk of collision*	*(C) Occasional*	*(VI) Catastrophic (this is the worst case)*	*(1) Flight Computer and Maintenance Computer will indicate "Left Main Brake, Pressure Low"*	*Built-In Test interval is 1 minute*	*Unacceptable*	*Check Dormancy Period and probability of failure*	*Require redundant independent brake hydraulic channels and/or Require redundant sealing and Classify O-ring as Critical Part Class 1*

Detailed design: Analysis and Modeling

- *Detailed Design analysis:*
  - *FMEA*
    - *Probability (P)*
    - *It is necessary to look at the cause of a failure mode and the likelihood of occurrence. This can be done by analysis, calculations / FEM, looking at similar items or processes and the failure modes that have been documented for them in the past. A failure cause is looked upon as a design weakness. All the potential causes for a failure mode should be identified and documented.*

Rating	*Meaning*
A	*Extremely Unlikely (Virtually impossible or No known occurrences on similar products or processes, with many running hours)*
B	*Remote (relatively few failures)*
C	*Occasional (occasional failures)*
D	*Reasonably Possible (repeated failures)*
E	*Frequent (failure is almost inevitable)*

Detailed design: Analysis and Modeling

- *Detailed Design analysis:*
  - *FMEA*
    - *Severity (S)*
      - *Determine the Severity for the worst-case scenario adverse end effect (state). It is convenient to write these effects down in terms of what the user might see or experience in terms of functional failures. Examples of these end effects are: full loss of function x, degraded performance, functions in reversed mode, too late functioning, erratic functioning, etc.*

Rating	*Meaning*
I	*No relevant effect on reliability or safety*
II	*Very minor, no damage, no injuries, only results in a maintenance action (only noticed by discriminating customers)*
III	*Minor, low damage, light injuries (affects very little of the system, noticed by average customer)*
IV	*Moderate, moderate damage, injuries possible (most customers are annoyed, mostly financial damage)*
V	*Critical (causes a loss of primary function; Loss of all safety Margins, 1 failure away from a catastrophe, severe damage, severe injuries, max 1 possible death)*
VI	*Catastrophic (product becomes inoperative; the failure may result in complete unsafe operation and possible multiple deaths)*

Project

- *Phase 6*
  - *Product FMEA Analysis*