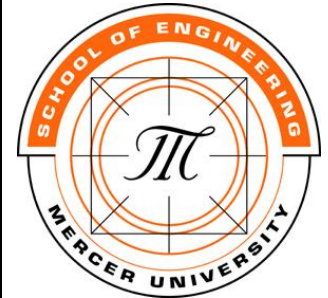


Introduction to Engineering Design Processes

XYZ – 487 Senior Design
School of Engineering
Mercer University

Loren Sumner



Refs:

ABET Criteria for Accrediting Engineering Programs 2012-13, criterion 5

Haik and Shahin, Engineering Design Process, 2nd ed., CENGAGE Learning, 2011.

Kroll, Condoor, and Jansson, Innovative Conceptual Design, Theory and Applications of Parameter Analysis, Cambridge, 2001

A Design process seeks a preferred solution



- Design problems are open ended and typically complicated
 - Open-ended problems have many possible feasible solutions
 - Problems involve many different needs and performance characteristics (various measures of success)
- A Design process seeks a preferred solution in some way
 - This requires more than an educated guess among feasible alternatives but a credible and substantiated better solution.
- A Design process constitutes a series of questions, investigations, and decisions

Engineering Design applies engineering principles



- It is a decision-making process leading to the specification of a (device, system, and/or process) that meets stated functionality and performance objectives.
- It applies knowledge of the
 - basic sciences,
 - mathematics, and
 - engineeringto optimally convert resources for a desirable solution

Refs: ABET Criteria for Accrediting Engineering Programs 2012-13, criterion 5

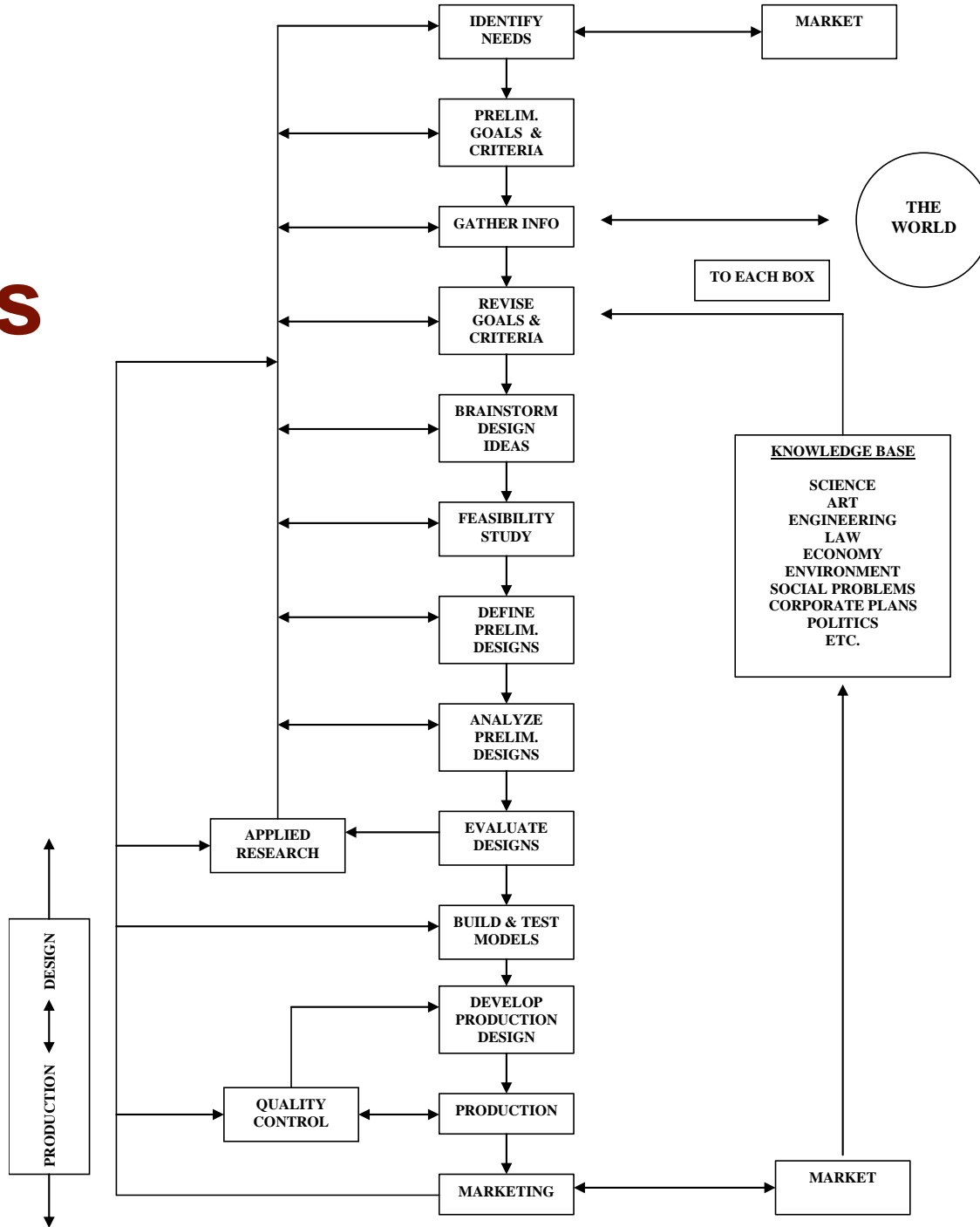
Haik and Shahin, Engineering Design Process, 2nd ed., CENGAGE Learning, 2011.

Possible Deliverables of Engineering Design



- Computer Software Files, Data files, Written Programs, etc
- Prototype, instrumentation, tools, etc
- Documentations,
 - Working drawings
 - Detailed set of specifications of final product and components
 - Recommendations, Substantiated Decisions
 - Explanations (needs analysis, performance predictions, etc)
 - Report of background research (technology review)
 - Findings (from analyses, technology reviews, etc)
 - Graphics of results, concepts, budget, etc
 - Interpretation of Findings
 - Instructions and/or hardware manuals

A Design Process



Another Design Process

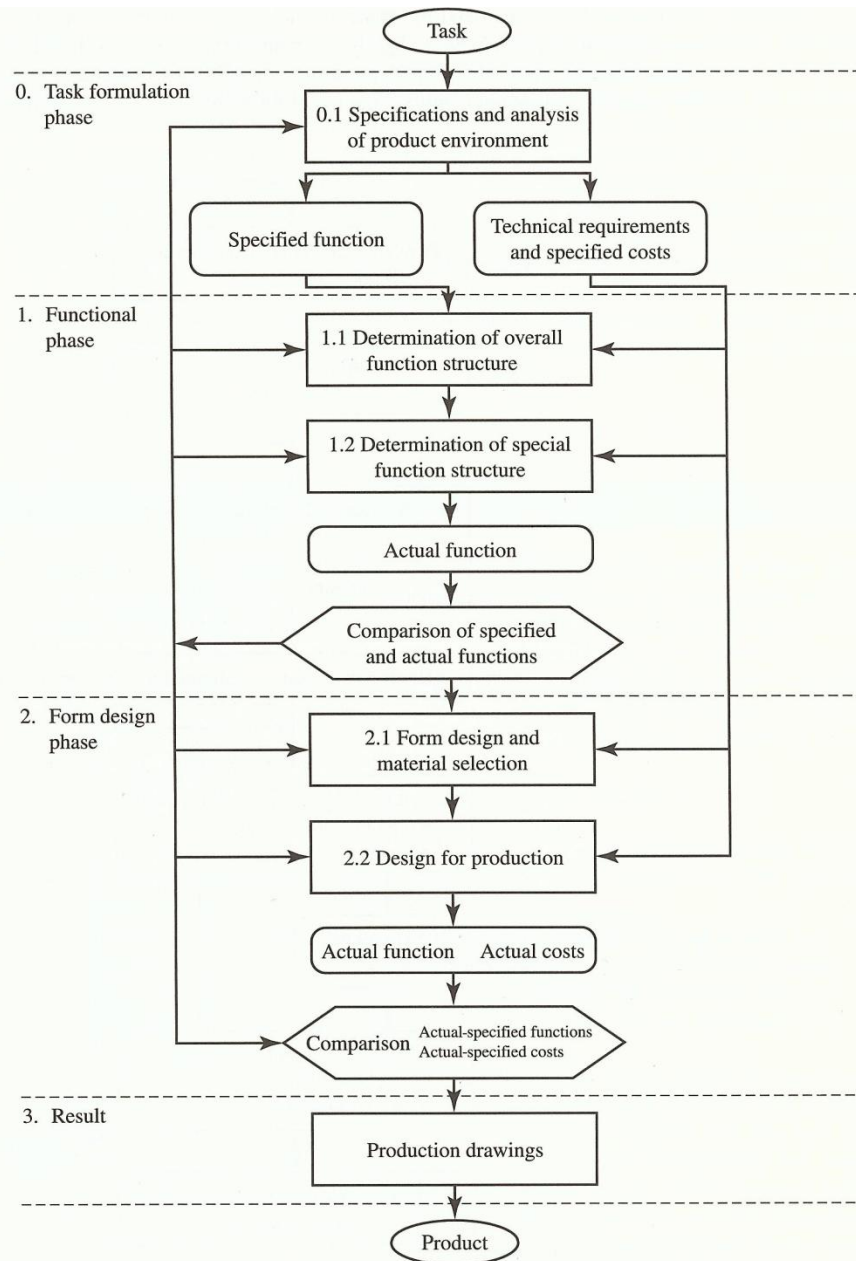
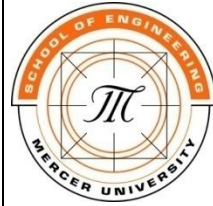
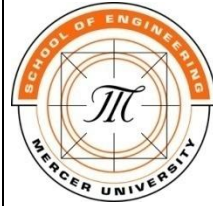
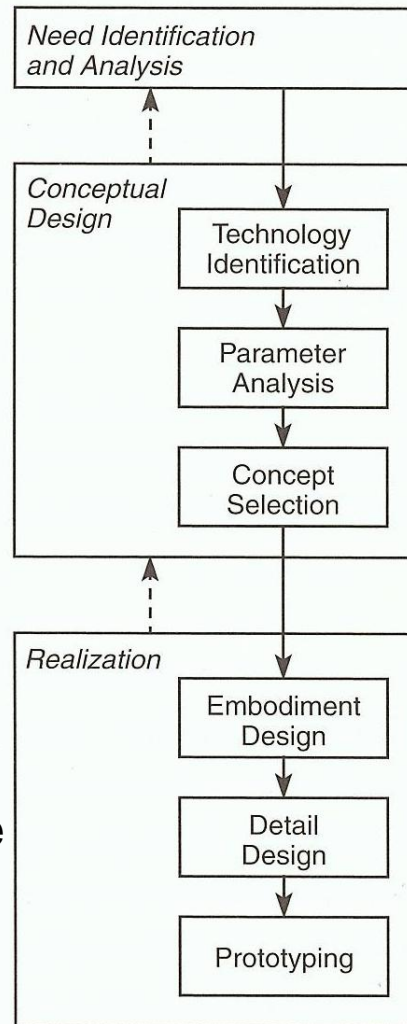


Figure 1.2 Design process map. (“Design Process Map” from ENGINEERING DESIGN: A SYNTHESIS OF VIEWS by C.L. Dym. Copyright © 1994. Reprinted with the permission of Cambridge University Press.)

Typical Design Processes



Creating a high-quality idea



Background research

Brainstorming

Merit Analysis

Details for clear definition

Final Specs (PDR) – end 487

Prototyping(Testing) - XYZ 488

Engineering Analysis – predictions, calculations, etc. leading to final specs

Realizing a high-quality device

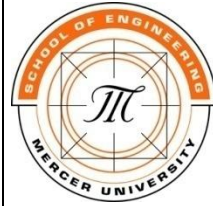
Figure 1.1 Overview of the engineering design process.

Needs Identification and Analysis



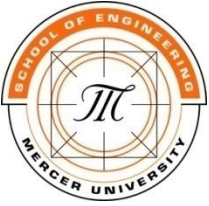
- Discovering/verifying the “real” needs
- Find and remove preconceptions
- Analyze the needs as to not preclude solutions due to a biased understanding
- Effectiveness of the conceptual design depends on how well the need is understood
- Important to overtly ensure objectivity in the early stages
- Develop engineering requirements and objectives for the project
- Plan a design process to arrive at a preferred solution

Engineering: Demonstrated application of what you've learned at MUSE



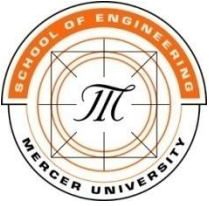
- Analog Filter Design
- Bioremediation
- Biological Fluids
- Biomechanics
- Chemical Processes
- Diagnostic Imaging
- Digital Logic and Comp. Organization
- Dynamics
- Electrical Fundamentals/ Circuits
- Electromagnetic Field Theory
- Engineering Design
- Engineering Economy
- Ergonomics
- Feedback Controls
- Fluid Mechanics/ Hydraulics
- Heat Transfer
- Human Factors Engineering
- Instrumentation/ Data acquisition
- Manufacturability
- Materials
- Microcomputer Fundamentals
- Probability and Statistics
- Power Electronics
- Robotics
- Signal Processing
- Solid Mechanics/ Structural analysis
- Quality Control
- Statics and Solid Mechanics
- Thermodynamics
- Vibrations

Topics are comparable with all accredited engineering schools across the country.



Basics of Decision Making

1. Clarify the issue needing a specific solution
2. Generate alternatives
3. **Develop criteria** to evaluate alternatives
4. **Identify criteria importance**
5. Evaluate
6. Decide next step
 - a. Refine, add, alternatives
 - b. Refine criteria and evaluation
 - c. Choose an alternative to invest resources



Design Criteria

- Developed from performance specifications
 - Ensure compliance with client's requirements
 - Use to discriminate between design ideas
 - Choose the idea to develop (w/ engineering analysis) into a specific device
- Two Types
 - Feasibility Criteria - Eliminate infeasible ideas
 - Merit Criteria - Compare merit of feasible ideas



Feasibility Criteria

- Factors that limit the scope of a project
- Normally expressed as constraints
 - unit must weigh less than 100 lbs.
 - unit must accelerate to a velocity of 60 mph in less than 10 seconds.
- Go / No-Go Criteria (Feasible / Not-Feasible)
- Project requirements are a primary source



Feasibility Analysis

- Eliminate some of the design concepts
- Reveal ways that other alternatives may overcome their limitations
- Produces at least two feasible alternatives
 - In practice, this will not always occur
 - For your projects – probably should
- A single table comparing each design to the feasibility criteria with pass/fail (✓ or X) notation is a common approach
 - Good visual of why designs are succeeding or failing

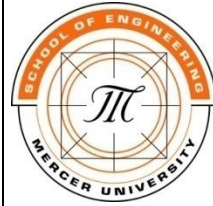


Merit Criteria

- Specific while still providing a basis for choosing between alternatives
- Examples include:
 - low unit production cost, low shipping cost, low storage cost, etc.
 - high acceleration, high velocity, high efficiency, etc.
- Relate closely to performance specs
- Contribute to overall project goals

Merit Analysis

Which concept is the most meritorious?



- Provide a logical method for selecting an alternative to develop
- Reference merit criteria – quantifiable factors that promote discrimination between **FEASIBLE** design alternatives.
- Should be presented in a form which will facilitate the decision making process
- Substantiates & facilitates good decisions

Lots of decision making tools

Principal-based decision making

PMI (Plus/Minus/Implications)

Probabilistic Risk Assessment & Risk- Based

Pareto Analysis

Cost/Benefit

Grid Analysis

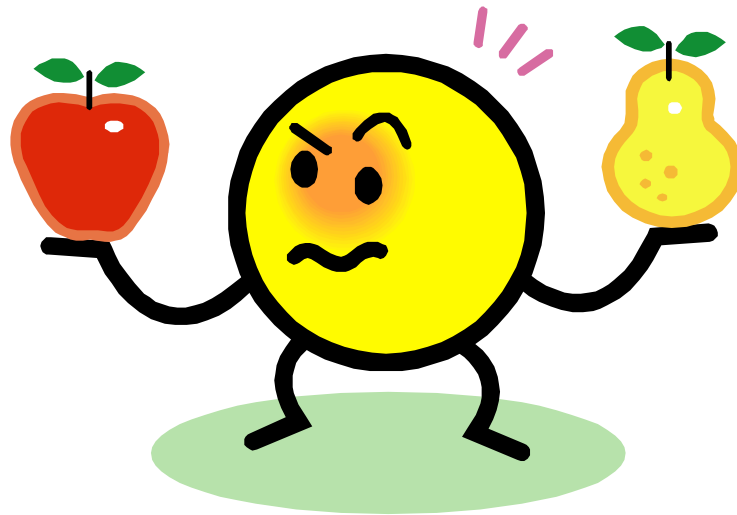
Paired Comparison

Decision trees

Six Thinking Hats

Force Field

...





The Decision Matrix – Pugh’s Method

	Weight	Features	Alt #1		Alt #2			Alt #3		
	(%)		Merit Factor	Total Merit	Features	Merit Factor	Total Merit	Features	Merit Factor	Total Merit
Functionality	40	7	7	280	9	9	360	8	8	320
Production cost	30	\$1000/unit	6	180	\$500/unit	8	240	\$750/unit	7	210
Operating cost	15	\$2.00/hr	6	90	\$4.00/hr	2	30	\$3.00/hr	4	60
System weight	10	60 lbs	6	60	70 lbs	2	20	50 lbs	10	100
Aesthetics	5	10	3	15	50	7	35	25	5	25
Total	100			625			685			715

