



SYLLABUS

09 October 2017

COURSE DESCRIPTION.

The design of artifacts is addressed from a multidisciplinary perspective that includes engineering, art, psychology, marketing, and economics. Using a decision-making framework, emphasis is placed on understanding basic quantitative methods employed by the different disciplines for making design decisions, and on the interdisciplinary interactions throughout the design development process. Students work in teams to apply the methods on a design project from concept generation to prototyping and design verification. The course is open to all seniors and graduate students (3 or 4 credits).

ME seniors must register for ME455 either to satisfy the ME450 capstone requirement (4 credits) or as an elective (3 credits). All graduates (ME, DESCI, other) must register for DESCI 501 as an elective (3 credits).

PREREQUISITES

Familiarity with undergraduate math requirements typical in engineering programs is expected. ME seniors must satisfy all ME450 prerequisites and other constraints. Non-ME students must have senior or graduate standing and should consult the instructor to confirm they have a suitable background for the course.

COURSEWORK

Students work in teams on a design project proposed by the team or by a sponsor. Project work includes:

- Definition of design intent. Concept generation. Early prototyping for concept exploration.
- Development of mathematical models for design decisions from engineering, economic, and marketing (user) perspectives. These will include use of engineering analysis tools and software, Excel-based economic analysis, and conjoint analysis.
- Conduct of scientific surveys to support user preference modeling
- Prototype construction to test design concept prior to finalizing the design

Some homework and short quizzes will be assigned to augment the lectures. Grades will be based approximately 20% on homework and quizzes, and 80% on project work. More details are discussed in class.

The amount of work is similar to that required in ME 450. Prototyping work is done earlier in the semester to allow time for redesign.

The class meets TuTh 1:30-3:30 pm in 165 Chrysler for regular lectures. Additional work in shops/labs is expected. All students must be certified to use the ME shops.

DETAILED TOPICS

The topics attached are addressed through regular lectures, study of references, guest lectures and project work. Most of the topic listed correspond to “modules” on the Canvas course site.

Analytical Product Design

A Design Science Approach

1 Designing in the Designed World

1.1 The Designed World

Personal Values • Team, Business and Social Values • Customer, Subject, User or Fellow Human? • Analysis and Synthesis, Qualitative and Quantitative Thinking • Evolving Nature of Artifacts • Design Thinking • Design Science

1.2 Design Process Models

Design as a Process • Intuitive Process Models • Formal Process Models • Process Models Values and Pitfalls

1.3 Analytical Design: Decision Making

The Decision-Making Paradigm • Optimal Design • Mathematical Optimization • Multicriteria Models • Nature of Model Functions • Configuration Design vs. Proportional Design • Systems and Components • Hierarchies and Decomposition

1.4 The Design Team

Individuals and Teams • Team Roles • Leadership • Team Decision Making

1.5 Prototyping

1.6 The Design Project

Organized Chaos • Checklists • Timelines

1.7 Design Project Activities

1.8 Summary

2 Defining the Design Problem

2.1 Solving the right problem

Design and Designers • The Why Cascade • Understanding the User • Understanding the Design Environment

2.2 Scenarios and Personas

2.3 Gathering Information: Needs and Wants

Observation • Interviews • Focus Groups • Market Data • Case Studies • Surveys • Conjoint Analysis

2.4 Surveys

2.5 Qualitative Analysis

2.6 Making Value: Design Problem Mapping

Attributes • Characteristics • Objectives • Requirements • Measuring Success

2.7 User Experience

2.8 The Business Context

Design Intent: User, Customer, Producer? • Market Composition • Variants and Platforms

2.9 Environmental Context

Eco-design • Product Life Cycle • Qualitative Assessment

2.10 Checking Your Values

Professional Ethics • Codes of Values • Sharing Values

2.11 Design Project Activities

2.12 Summary

3 Creating Designs

- 3.1 Concept Generation, Prior Art and Patents
Prior Art • Intellectual Property • Patentability • Patent Search
- 3.2 Creativity, Ideation, Blockbusting
Creativity and Design • Stimulators and Blocks • Perceptual Blocks • Emotional Blocks • Cultural Blocks • Organizational and Situational Blocks • Expressive Blocks • Brainstorming • Morphological Analysis • Synectics
- 3.3 Function Analysis and Decomposition
Primary and Secondary Functions • Function Structure and Decomposition • Multifunctional Components, Efficiency and Reliability
- 3.4 Reverse Design
Reverse Analysis • Benchmarking • Finding Gaps
- 3.5 Design Heuristics
Cognitive Heuristics • Designing with Heuristics
- 3.6 Quick prototyping
Visual Thinking • Sketching • Hands-on Reality • Digital Prototyping
- 3.7 Surveys and Conjoint Analysis
- 3.8 Adaptive Smart Design
- 3.9 Computational Design
- 3.10 Concept Selection and Embodiment Design
Mapping Functions to Objects • Concept Demonstration • Path to Realization
- 3.11 Construction of Alpha Prototype: Concept Demonstration
- 3.12 Design Project Activities
- 3.13 Summary

4 Designing for Humans

- 4.1 Designing for the Human Body and Mind
- 4.2 Eliciting Preferences
Revealed Preferences • Stated Preferences • Individual and Aggregate Preferences
- 4.3 Crowdsourcing, Big Data and Collaborative Design
Interactive Design • Crowdsourcing • Big Data • Collaborative Design
- 4.4 The Physical Human
Ergonomics and Human Factors • Anthropometry: Human Variability • Young and Old • Interaction Design
- 4.5 Cognitive Ergonomics
Cognition • Human-Computer Interaction • Neuroergonomics
- 4.6 Emotional and Aesthetic Design
Emotional Processing • Objects as Symbols • Pleasure • Proportionality • Craftsmanship
- 4.7 Kansei Analysis
- 4.8 Universal Design
Design for All • Universal Design Principles • Design Standards
- 4.9 The Human in the System
Unintended Use • Maintenance and Service

4.10 Design Project Activities

4.11 Summary

5 Embodiment and Evaluation

5.1 Continuous Evaluation

Qualitative Evaluations • Quantitative Evaluations • Team Evaluations • External Evidence

5.2 Evaluating Concepts

Design Selection Matrices • Surveys

5.3 Embodiment and Detailed Design

Product Realization • Forms and Layouts • Manufacturing and Materials • Evaluation

5.4 Functionality

Analysis and Simulation • Virtual Prototypes • Physical Prototypes

5.5 Design and Control

5.6 Analytical Design: Optimization

Design Requirements • Design Objectives • Design Constraints • Variables, Parameters and Constants

5.7 Solving Optimal Design Problems

Boundedness Analysis • Gradient-Based Methods

5.8 Materials

Bill of materials

5.9 Manufacturing

Custom vs. off-the-self parts • Parts and assembly • Production

5.10 Sustainability

Quantitative Assessment • Life Cycle Analysis • Sustainability as an Objective

5.11 Construction of Beta Prototype: Functionality Validation

5.12 Design Project Activities

5.13 Summary

6 Modeling the Producers

6.1 From Design to Product

6.2 The Nature of Cost

Cost vs. Benefit • Fixed and Variable Cost • Investment Cost • Cost Modeling • Bill of Materials

6.3 Demand: Classic Microeconomic Model

Linear Demand • Price Sensitivity and Price Elasticity • Design Sensitivity and Elasticity

6.4 Integration of Design in the Enterprise

Profit as an Objective • Functionality as Constraints • Enterprise Optimization

6.5 Demand: Marketing Models

Conjoint Analysis • Design Part Worths • Heterogeneity

6.6 Producers' Optimization: Refinements

Using Marketing Models for Demand • Market Equilibrium • Government Regulations and Policies

6.7 Design Project Activities

6.8 Summary

7 Building a Business Plan

7.1 From Product to Value

Making Value • For Profit or Not

7.2 Interest

Time Value of Money • Simple Interest • Compound Interest • Present Worth

7.3 Investment Economics

Cost Benefit Analysis • Net Present Value Method • Annual Cost Method • Rate of Return Method • Break-Even Point Method • Taxes and Depreciation

7.4 Elements of a Business Plan

Business Opportunity • Product Description • Market Analysis • Capital and Human Resources

7.5 Financial Data

Capital Equipment and Supply • Investment Analysis • Profit and Loss Statement

7.6 Supporting Data

Prior Art • Existing Patents • Technical Analysis and Benchmarking

7.7 Investing in People

7.8 Design Project Activities

7.9 Summary

8 Reflection and Practice

8.1 Delivering on Design Reflections

First Reflection: Design Problem • Second Reflection: Product Concept • Third Reflection: Product Embodiment • Fourth Reflection: Business Plan • Grading

8.2 Oral Presentations

8.3 Preparing for Iterations

Shedding the Timeline Tyranny • Using Your Process Model • Communication

8.4 Building Models

Appropriate Models • Software • Hardware • Resources

8.5 Integration

One Design, Many Designers • Multidisciplinarity • Product and System Design

8.6 The Limits of Analysis

8.7 Project Checklists

Problem Identification • Initial Problem Objectives • Functionality Analysis Models • Alpha Prototype • Optimizing for Functionality • Microeconomic Demand Models • Optimizing for the Enterprise • Beta Prototype • Marketing Demand Models • Revised Enterprise Design Model • Final Prototype • Business Plan

8.8 The Wages of Good Design

8.9 Design Project Activities

8.9 Summary