

MAE 526 (DE): Fundamentals of Product Design
Summer 2024

SYLLABUS / SEMESTER PLAN

Instructor	Office Hours (via Zoom)
Dr. Scott Ferguson smfergu2@ncsu.edu	Mondays and Thursdays 8:30 pm – 9:30 pm EST or by scheduled appointment

Course lectures

We are using lectures recorded during the spring of 2024. **There are two ways of accessing the course lectures.** The lectures can be found in the following Panopto folder:

<https://ncsu.hosted.panopto.com/Panopto/Pages/Sessions/List.aspx?folderID=08369c45-7a61-48f2-a02d-b0d50176469c>

There is also a link to the Engineering Online page for the class on the course Moodle site. After clicking on the link, you will see a box labeled 'Lecture Videos'. Clicking on this box will take you to the Panopto folder. There is also the EOL Download form that must be filled out so you can download lecture videos.

A copy of my annotated notes for each lecture are posted on the course Moodle site.

Course websites

Moodle: <http://wolfware.ncsu.edu>

Office hours – Mondays and Thursdays from 8:30 pm – 9:30 pm eastern (via Zoom)

Zoom link (office hrs): <https://ncsu.zoom.us/j/92235629290?pwd=ZWMvckdMUUswYkQwWFRiUnpTTERNUT09>
Meeting ID: 922 3562 9290 Passcode: 507611

Course description

The growing body of research in the engineering design community provides approaches for navigating the design of consumer products using interdisciplinary design tools and economic models based on the construct of rational decision making. This course introduces scientific engineering design techniques that are more effective than “ad hoc” tactics. By exploring how engineering principles integrate with “real world” design challenges, students will learn how they can more effectively solve product design problems that encompass heterogeneous markets, multiple disciplines, and complex systems.

Learning objectives

At the end of this class, you will understand how design can be approached systematically and will be able to:

- Define and analyze customer needs in product design
- Create alternative solutions using brainstorming techniques
- Define the core components of a product
- Synthesize information from multiple disciplines and multiple objectives when designing a product
- Apply appropriate techniques for capturing/representing heterogeneous preferences of a consumer market
- Demonstrate the use of customer preferences and requirements in models of demand
- Apply product design strategies when accounting for sources of consumer variability
- Analyze alternative solutions and scientifically identify the best candidates
- Demonstrate how uncertainty can be modeled in the design process
- Assess the environmental impact of a product by considering the product’s lifecycle
- Critique how current design research advancements will see use in the next 15-20 years

Text(s)

There is **no** required textbook. Additional readings and references will be provided by the instructor. These optional textbooks will also be used as references throughout the course:

Ulrich, K. T., and Eppinger, S. D., 2011, Product Design and Development, 5th edition, Cambridge University Press, Cambridge, UK.
Otto, K., and Wood, K., 2000, Product Design: Techniques in Reverse Engineering and New Product Development, Prentice Hall, New York, NY.
Dieter, G., and Schmidt, L., 2013, Engineering Design, 5th edition, McGraw-Hill, New York, NY.
Lewis, K. E., Chen, W., and Schmidt, L. C., 2006, Decision Making in Engineering Design, ASME, New York, NY.

Course topics

- Introduction to product design and product development processes
- Market growth, task planning and customer requirements
 - Bass diffusion model
 - Critical Path Method and PERT
 - Kano model and customer needs
 - Defining product requirements
- Conceptual design
 - QFD and House of Quality
 - Functional decomposition, Axiomatic design
 - Brainstorming techniques, Pugh Concept Selection technique
 - Innovation and creativity
- Embodiment design
 - Determining product value
 - S-Model, Conjoint analysis and Discrete choice when modeling customer preferences
 - Linking the design space, the performance space, and business objectives
 - Establishing a product architecture and understanding functional relationships
 - Product platforms and product families
 - Design for variety and product customization
- Engineering design decision-making and limitations of existing approaches
 - Mathematical validity / provability of techniques
 - Challenges of concept selection
 - Uncertainty in engineering design
 - The mediation and combination problem of decision-making
- Advanced design perspectives
 - Sustainable product design
 - Engineering design for global development

Teaching philosophy

“The lasting measure of good teaching is what the individual student learns and carries away.”
Barbara Harrell Carson, 1996, *Thirty Years of Stories*

I will try my best to answer all email questions within one business day. If you experience problems with the material, please contact me for help.

Grading and grade scale

<u>526 students</u>	
Homework (6 in total)	45%
Project 1	20%
Project 2	15%
Design topic essay	20%

The following grade scale will be used for assigning final grades. The instructor reserves the right to scale-up final grades based on the class average.

A+	A	A-	B+	B	B-	C+	C	C-
>=98	93 - < 98	90 - < 93	87 - < 90	83 - < 87	80 - < 83	77 - < 80	73 - < 77	70 - < 73

D+	D	D-	F
67 - < 70	63 - < 67	60 - < 63	< 60

Homework

Homework is completed individually. All assignments must be submitted by the time posted on Moodle. Students are allowed one 24-hour grace period on one assignment. Students should discuss issues with the professor as soon as they become known. Late assignments submitted without communication, and not used as part of the one grace period, will not be accepted without justification. Students are recommended to see the University Attendance Policy for reasons that late homework may be accepted.

Project 1

The first project focuses on the relationship between market opportunities, customer needs identification, and solution-neutral concept generation. You will identify a customer who has a problem that you can solve with a new product offering. The project will be completed individually.

Project 2

The second project focuses on the relationship between system design variables, system attributes, and demand. Contextually, we are considering three blocks on Hazelrigg's proposed framework for Decision-based Design. In this project, the outcome will be the identification of relevant system attributes (a) and describing the corresponding technical mapping that exists between system attributes and system design variables (x). Conjoint analysis will be used in the second part of this project.

Design topic essay

For the last 20+ years, ASME and the National Science Foundation (NSF) have sponsored a student essay competition. The goal of this competition is to "encourage students to think about the future of engineering design and the intellectual foundations which are essential for the development of the field."

Your project consists of the following elements: (1) select one of the 7 ways that a firm might use data-driven decision-making in the year 2040, offered by ChatGPT, as your focus area, (2) read and summarize peer-reviewed journal papers that describe the latest, state-of-the-art engineering design advancements in the focus area you selected, (3) summarize how these articles collectively address the challenge of data-driven decision-making in support of the design process, particularly in the context of Isaksson's and Eckert's report, and (4) describe what future work is needed in your selected focus area.

Exams

There are no exams during this summer offering of the course.

Other rules and regulations

Course Attendance:

NC State attendance policies can be found at: <https://policies.ncsu.edu/regulation/reg-02-20-03-attendance-regulations/>.

Academic Integrity

Cheating of any kind (copying, plagiarism, etc.) will not be tolerated and will result in an F for the course. Students are required to comply with the university policy on academic integrity found in the Code of Student Conduct found at <http://policies.ncsu.edu/policy/pol-11-35-1>. See <http://policies.ncsu.edu/policy/pol-11-35-1> for a detailed explanation of academic honesty.

Use of Online Exchanges

Students may be required to disclose personally identifiable information to other students in the course, via electronic tools like email or web-postings, where relevant to the course. Examples include online discussions of class topics and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

Policies on Incomplete Grades

If an extended deadline is not authorized by the instructor or department, an unfinished incomplete grade will automatically change to an F after either (a) the end of the next regular semester in which the student is enrolled (not including summer sessions), or (b) the end of 12 months if the student is not enrolled, whichever is shorter. Incompletes that change to F will count as an attempted course on transcripts. The burden of fulfilling an incomplete grade is the responsibility of the student. The university policy on incomplete grades is located at <http://policies.ncsu.edu/regulation/reg-02-50-3>.

Accommodations for Disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, student must register with the Disability Services Office (<http://www.ncsu.edu/dso>), 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation at <http://policies.ncsu.edu/regulation/reg-02-20-1>.

Non-Discrimination Policy

NC State University provides equality of opportunity in education and employment for all students and employees. Accordingly, NC State affirms its commitment to maintain a work environment for all employees and an academic environment for all students that is free from all forms of discrimination. Discrimination based on race, color, religion, creed, sex, national origin, age, disability, veteran status, or sexual orientation is a violation of state and federal law and/or NC State University policy and will not be tolerated. Harassment of any person (either in the form of quid pro quo or creation of a hostile environment) based on race, color, religion, creed, sex, national origin, age, disability, veteran status, or sexual orientation also is a violation of state and federal law and/or NC State University policy and will not be tolerated. Retaliation against any person who complains about discrimination is also prohibited. NC State's policies and regulations covering discrimination, harassment, and retaliation may be accessed at <http://policies.ncsu.edu/regulation/reg-04-25-2> or http://www.ncsu.edu/equal_op/. Any person who feels that they have been the subject of prohibited discrimination, harassment, or retaliation should contact the Office for Equal Opportunity at 919-515-3148.

NC State Policies, Regulations, and Rules (PPR)

Students are responsible for reviewing the NC State University PRR's located at <http://oucc.ncsu.edu/course-rights-and-responsibilities> which pertains to their course rights and responsibilities.

Course outline (dates, topics, and assignments all subject to change)

<u>Week</u>	<u>Topic</u>	<u>Lectures to watch</u>	<u>Assignment</u>
1	Introduction to product design Product development processes	1, 2, 3	-
2	Product development processes Market growth modeling and task planning Customer needs and requirement definition	4, 5, 6	HW1 due (5/23)
3	Customer needs and requirement definition QFD and the House of Quality	7, 8	HW2 due (5/30)
4	QFD and the House of Quality Functional decomposition Brainstorming and innovation	9, 10, 11	HW3 due (6/6)
5	Brainstorming and innovation Product value and the S-model	12, 13	-
6	Product value and the S-model	14, 15	Project 1 due (6/17)
7	Conjoint analysis	16, 17	HW4 due (6/24)
8	Discrete choice analysis	18	HW5 due (7/1)
9	Discrete choice analysis	19, 20, 21	Project 2 due (7/11)
10	Product portfolios and product families Design for the environment (LCA)	22, 23, 24	HW6 due (7/18)
11	Decision-making in engineering design	25, 26, 27	Essay due (7/25)
12			Grades due (8/1)