COURSE SYLLABUS

ISE-501/AME-501: Innovative Conceptual Design for New Product Development

Spring Semester, 2025

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Course Section: 31501D (on-campus) 31798D (DEN)

Course Unit: 4 Units

Prerequisite: A graduate student standing in engineering is required (or with a special approval by the instructor).

Class Hours: Tuesdays, 5:00 pm to 8:20 pm*

- 5:00 pm to 5:30 pm – Announcements & Assignment Explanations
- 5:30 pm to 5:40 pm – session break
- 5:40 pm to 7:00 pm – Review & Learning activities
- 7:00 pm to 7:10 pm – session break
- 7:10 pm to 8:20 pm – Pre-recorded Lecture* / Office Hours

* This is a flipped classroom—students can watch the weekly pre-recorded lecture, which is around an hour long, at any time within the week.

Class Location: Ronald Tutor Hall (RTH) 217

Office Hours: 7:10 pm to 8:20 pm, on Tuesdays @RTH 217

Email request is required for the appointments out of the office hour window

- Zoom: https://usc.zoom.us/my/drwang
- The email is usually replied within 48 hours

Teaching Assistant: Han Kyul Kim

- Email: hankyulk@usc.edu
- Office Hours: TBD

Course Description:

As the competitions for more function, higher quality, lower costs, swift delivery and life-cycle accountability of products and systems intensify rapidly, product development has been no longer focused on optimization. To succeed on today's highly-competitive global technology market, the company must totally revamp the traditional product development processes and systems thinking so that designers can creatively "do-the-right-thing" first, and then effectively "do-the-thing-right". Having a strategic way to develop products from upstream has become more and more important. Conceptual design is an early stage in design process. It determines more than 70% of the total costs and performance of the product. However, conceptual design can not be directly implemented by the engineering principles and mathematic formulas from technical design because concepts are abstract and lack of values. Therefore, this course aims to teach a systematic conceptual design approach that helps engineering students understand decision principles and design theories in conceptual design, and be able to develop design concepts that not only creative but also logically feasible.

This graduate-level course will start from covering the fundamental decision principles, logic foundations, relevant design theories for conceptual design, and then introduces an "innovative design thinking" (IDT) framework and "Design Coupling Sequence" (DCS) methods which can systematically guide rational and optimal engineering decisions through conceptual design including concept generation phase and concept improvement phase for product development. Real-world examples of using IDT and DCS in various product industries will be included to help the students' understandings of the basic concepts.

Course Goal and Learning Objectives:

The goal of this course is to prepare students with the necessary foundations and skills to become an innovative design thinker who can ideate design concept creatively and rationally, and refine the design practically as ideal as possible. In a typical undergraduate engineering design curriculum, main focuses are placed on using physics-based engineering knowledge to perform technical analyses to support evaluations of mechanical components design. Some advanced-level undergraduate design courses briefly discuss design theories and methodologies, with emphases on specific design procedures. These analysis-based design approaches, which are mostly "bottom-up" in nature, and procedural-oriented design processes, which are without deep theoretical understandings, are not sufficient for students to deal with the real-world design tasks when they join the industrial workforce, nor to comprehend the state-of-the-art of engineering design research when they enter the graduate school.

As the first graduate-level engineering design course at the ISE and AME department and a program required course of the Master of Science in Product Development Engineering (MSPDE) degree, this course - Advanced Conceptual Design for Product Development bridges the gaps between students' undergraduate education in engineering components design (i.e., bottom-up and analysis-based) with graduate-level advanced issues in engineering systems design (i.e., top-down, synthesis-based). Following the innovative design thinking framework, the students will learn how to rationally identify break-through design opportunities from market intelligences and then carry out innovative conceptual designs during a new product development process. Equipped with knowledge from this course, the students should have sufficient backgrounds to utilize proven design theories, methods and techniques developed from recent design researches to enhance their abilities to perform advanced engineering design of technical products, processes, and systems. In short, this course is an important transition from the undergraduate-level bottom-up analysis-based components design to the graduate-level top-down synthesis-based systems design.

The specific learning goals of this course include:

1. Understand the Innovative Design Thinking (IDT) framework, which consists of "do-the-right-thing" rationally and "do-the-thing-right" optimally.
2. Clarify the notions of social and brute realities, the concepts of rationality and optimality, and their different roles in the conceptual design of product/system developments.
3. Understand conceptual design phases and their applicable design theories and methodologies.
4. Learn the basics of innovation theories and techniques for concept generation phase including the Axiomatic Design theory, Innovative Design Thinking, decision-making techniques.
5. Learn the basics of concept improvement methods and tools for concept improvement phase such as TRIZ (Inventive problem-solving method), Extended Algorithm methods, modular design, and Design Coupling Sequence (DCS) approach, and how they can be used in a complementary manner to support innovative design thinking.
6. Practice applying those methods and principles in real design cases within in-class exercises, homework assignments, and team projects.
7. Practice the IDT concept generation process and basic design axioms to generate and compare initial design concepts through direct synthesis reasoning (vs. iterative analyses).
8. Practice the usage of DCS methods to improve initial design concepts by formulating execution sequences and refining the design concept by function modules.
9. Put all the innovative design thinking principles and practices together in a big picture of complex engineered systems to highlight the key takeaways of the course.

Textbooks:

There is no required textbook for this course, and some recommended reference books include (items 1 and 2 in bold-face are the key references):

1) **"Axiomatic Design – Advances and Applications", by Nam P. Suh, the Oxford University Press.**
2) **"Systematic Innovation – an introduction to TRIZ", by John Terninko, Alla Zusman, and Boris Zlotin, St. Lucie Press.**
3) "*Platforms, Markets and Innovation*", edited by Annabelle Gawer, Edward Elgar Publishing.
4) "*Smart questions: Learn to ask the right questions for powerful results*", by Gerald Nadler and William Chandon, John Wiley & Sons.
5) "*Creating Breakthrough Products – Innovation from Product Planning to Program Approval*", by Jonathan Cagan and Craig M. Vogel, Financial Times, Prentice Hall.

6) “*Complexity: Theory and Applications*”, Nam P. Suh, Oxford University Press, USA
7) “*The Design of Things to Come: How Ordinary People Create Extraordinary Products*”, by Craig M. Vogel, Jonathan Cagan, and Peter Boatwright, Wharton School Publishing.
8) “*The Sciences of the Artificial*”, by Herbert A Simon, MIT Press.
9) “*Product Design – Techniques in Reverse Engineering and New Product Development*”, by Kevin Otto and Kristin Wood, Prentice Hall.
10) “*Engineering of Creativity – Introduction of TRIZ Methodology of Inventive Problem Solving*”, by Semyon D. Savransky, St. Lucie Press, CRC Press Company.

The instructor may recommend additional reading materials and website reference resources during the semester whenever appropriate.

Course Website:
Students' learning of this course is supplemented by a course website (BrightSpace) on DEN instruction system (https://courses.uscden.net/d2l/home/30094). All registered students have access to this website (Spring 2025 > ISE-501). Students should browse the entire site to familiarize themselves with the various areas and functions.

Learning Modules:
The course is organized in the following 11 learning modules, each will be delivered in a pre-recorded lecture and reviewed/practiced in a live class.

M1 Product Development and Innovative Design Thinking (IDT)
M2 IDT Functional Design
M3 IDT Conceptual Design Overview
M4-6 Concept Generation Phase
M7-10 Concept Improvement Phase
M11 Concept Modeling and Evaluation

Lecture Format:
This is a flipped-classroom course. Each learning module is executed as follows:
- Dr. Wang posts lecture notes and a pre-recorded lecture video on course website on **Tuesday**.
- Students watch the pre-recorded video to learn the lecture content at any time from Tuesday to Sanday.
- Students post feedback on the course content (such as questions, insights, relevant examples, etc.) on the course website before the end of **Sunday**.
- Dr. Wang reads students' feedback and prepare for the live class before the Tuesday live class.
- Students learn in live class with lecture review and in-class exercises instructed by Dr. Wang during Tuesday live class.
- Dr. Wang holds office hours at the classroom after the live class for students to ask questions in person.

Course Grading:

Students will be graded according to the following scheme:

- **35% -- active learning activities**
  - **(10%) ten (10) lecture feedback posts**
  - **(25%) five (5) in-class exercises**
- **35% -- individual learning by doing**
  - **(20%) individual design project report**
  - **(10%) individual design project presentation**
  - **(15%) individual Provisional Patent Application (PPA) report**
- **30% -- collaborative learning by doing**
  - **(15%) team project final presentation**
  - **(15%) team project final report**
- **Up to 6% -- extra credits**
  - **(1%) post feedback for all video lectures**
  - **(5%) case study report**

Total: **100%**

Lecture Feedback Posts (10%+1% extra)

Students are required to submit their feedback on at least 10 out of 11 video lectures (11 learning modules) on the corresponding discussion board by the Sunday prior to each Tuesday's live class. This is an important checkpoint for the instructor to gauge students' learning efficiency and prepare for the live class lecture. The posts can be questions regarding the lecture, personal insights, real-world examples, or any related content.
Students will earn full credits (1%) for each post as long as they post their feedback before each deadline. This means students can have one missing feedback post or earn 1% extra credit for perfect attendance.

In-Class Design Exercises (25%)

Five In-Class design exercises are designed to assist students understand and assimilate the important concepts in some learning modules. To learn by following and then creating, the instructor will assign a few detailed and specific design exercises for students to reflect the key lecture content. The purpose of such exercises is to deepen student's theoretical understanding of the key concepts and to enhance student's practical capability of employing certain design principles to address real-world problems.
Students will form 3 - 6 member groups themselves for these exercises, with several groups consisting of students physically present, and other groups consisting of the DEN students completing the exercises electronically. For on-campus students, the hardcopy results must be submitted right after the class on behalf of the group. For the DEN students who are not able to attend class physically, considering communication difficulties, the results must be submitted to the assignment folder on our course website in 5 days (before

Sunday midnight (i.e. 12AM on Monday)) on behalf of the group. A total of 5 exercises will be assigned, making each exercise count 5% of your semester grade.

Individual Project (20% Report, 10% Presentation, and 10% PPA Report)

This class emphasizes the importance of learning by doing. The best way to understand the methods is to practice. Each individual student will work on an individual design project, to begin the product development process. Students will follow the instructions to select their design target and will further work on it as a design project. Design tasks and techniques will be assigned and taught in class. Students require to follow the instructions to complete the design tasks step by step. At the midterm, each student will submit a report and give a presentation on their work.

Students are then further required to convert their individual project final results as a Provisional Patent Application (PPA) report with their innovative perspectives, according to the requirements defined by the U.S. Patent and Trademark Office (http://www.uspto.gov). All the required sections and necessary information of a typical PPA, as specified by the U.S. Patent and Trademark Office, must be included in the PPA report. A list of "patent claims" should include all technical details and justifications to be reviewed and evaluated for their innovativeness.

Team Project (15% Presentation and 15% Report)

The best way to learn advanced conceptual design for innovative product development is to work on a real product development project. Several design teams, each with 3-6 students (depending on the final class enrollment number), will be organized to design a new product/service following the innovative design thinking (IDT) framework. Selecting a problem statement from one of their team members' individual project subjects, every design team is to improve the design concepts by applying the design improvement methods learning from the lectures. The final project deliverable will be the conceptual design of a technical system that can satisfy the design target. The design concepts must be represented as virtual or physical models that clearly illustrate/explain the working principles and how they function as function modules to satisfy the customer needs. No construction of live-scale real systems nor physical prototypes is required.

Each team is required to give a presentation and submit a report to explain their design and product improvements. Each team will receive a team grade based on their presentation and report, and then the grade will be adjusted according to the team contribution survey results for individual grades.

Extra Credit- Case Study Report (5%)

Relevant research papers will be posted for detail readings and comments. Students, who write a study report with a/some product design case(s) according to the papers, will be given up to 5% credits. It is considered as a formal study report, which should include

1. a cover page with the report title, the author's name and affiliation, and submission date,
2. a page of Table of Content,
3. Content pages with section and figure numbers and titles. (12 pt, type, typewritten, double-spaced, with

maximum 1" margins)

    a. A section of paper summary
    b. A section of the studied case(s)- description & analysis
    c. A section of discussion
    d. A section of conclusion

4. a page of References

There is no page limitation, but please be concise and clear. Please use/convert the file in the format of PDF (*.pdf) or WORD (*.doc, *.docx).

Please avoid doing copy-and-paste the content of the paper or using AI to support paper writing. We will use Turnitin and GPTZero tools to check the report.

Grading Scale

Course final grades will be determined using the following scale

A	91%-100%
A-	86%-90%
B+	81%-85%
B	76%-80%
B-	71%-75%
C+	66%-70%
F	65% and below

Late Assignments

Late Assignments are accepted except for the case study report, but they are with the following deductions. Do not wait until the last minute to upload. Unless there an emergency (in which case exceptions will be made) late assignments will have the following grades.

- 1 second to 5 minutes after deadline: -1% of assignment grade
- 5 minutes to 24 hours after deadline: -10% of assignment grade
- 24 to 72 hours after deadline: -25% of assignment grade
- 3 to 7 days after deadline: -50% of assignment grade
- More than 1 week after deadline before the final exam day: -75% of assignment grade

Please note that all emergency situations will require documentation (doctors note, police report, etc.). Losing internet access or power outages do not classify as an emergency. (Be sure to submit before the deadline to account for things like internet outages.)

<u>Course Schedule</u>:

A tentative course schedule, which includes weekly learning subject and activities, is as follow. The instructor reserves the right to change this schedule during the semester to better fit students' learning needs and progresses.

Week	Class Date	Learning Subject	Activities by Sunday/Deadlines
1	01/14	**Course Introduction (+ M1 Self-paced study)**	• Watch & Post M1
2	01/21	**M1.** Product Development and IDT	• Watch & Post M2
3	01/28	**M2.** IDT Functional Design	• Watch & Post M3
4	02/04	**M3.** IDT Conceptual Design Overview • Design Exercise 1 (tentative)	• Watch & Post M4
5	02/11	**M4.** Concept Generation Phase I	• Watch & Post M5
6	02/18	**M5.** Concept Generation Phase II • Design Exercise 2 (tentative)	• Watch & Post M6
7	02/25	**M6.** Concept Generation Phase III • Design Exercise 3 (tentative)	• Schedule Consultation
8	03/04	**Individual Project Presentation**	Individual Project Report (03/09) • Watch & Post M7
9	03/11	**M7.** Concept Improvement Intro	
10	03/18	Spring Recess	• Watch & Post M8 PPA (03/23)
11	03/25	**M8.** Concept Improvement Phase I • Design Exercise 4 (tentative)	• Watch & Post M9
12	04/01	**M9.** Concept Improvement Phase I • Design Exercise 5 (tentative)	• Watch & Post M10
13	04/08	**M10.** Concept Improvement Phase III	• Watch & Post M11
14	04/15	**M11.** Concept Modeling and Evaluation	• Schedule Consultation Case Study (04/20)
15	04/22	**Project Consultation Week**	
16	04/29	**Team Project Presentation**	Peer Evaluation (05/04)
17	05/06	**Study Week**	Team Project Report (05/06)

Academic Integrity:

"The Viterbi School of Engineering adheres to the University's policies and procedures governing academic integrity as described in SCampus. Students are expected to be aware of and to observe the academic integrity standards described in SCampus, and to expect those standards to be enforced in this course."

Students with Disabilities:

Any Student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m. - 5:00 p.m., Monday through Friday. The phone number for DSP is (213)740-0776.