

Summer Session 1 - 2011

AME503: Advanced Topics in Mechanical Design

COURSE SYLLABUS

Instructor: Yan Jin, Ph.D.

Professor of Aerospace and Mechanical Engineering,

Office: Room 400D, Olin Hall of Engineering

Phone: 626-538-5615

Email: yjin@usc.edu

Website: <http://bcf.usc.edu/~yjin>

Course Section:	28880R (for on-campus students) 29050R (for off-campus students)
Course Unit:	3 Units
Prerequisite:	A graduate student standing in engineering is required. (Or with a special approval by the Instructor) <i>This is a required course for MSPDE (the Master of Science in Product Development Engineering)</i>
Class Hours:	Mondays and Wednesdays, 5:30pm to 8:10pm <ul style="list-style-type: none">• 5:30pm to 6:45pm (75 minutes) – Session I• 6:45pm to 6:55pm (10 minutes) – Session break• 6:55pm to 8:10pm (75 minutes) – Session II
Class Location:	Room – RTH-115
Office Hours:	1:00pm to 2:30pm, on Mondays <ul style="list-style-type: none">• Face-to-face meetings held in 430H, OHE/USC• Phone meetings via 626-538-5615• Internet meetings: Skype ID: goosejin Googletalk: yjin10@gmail.com
Grader:	Mr. Chang Chen Office: BHE-B13; Email: changche@usc.edu Phone: 213-740-9621

Prelude - Design in Engineering:

Design is the essence of human intelligence in general, and the engineering profession in particular. Designers create purposeful artifacts, such as functional products, valuable services, and technical systems, to fulfill rapid changing societal needs. In today's technology-driven society, the economic growth is largely determined by engineer's performance and effectiveness in engineering design. The ever-increasing demands for product functions, coupled with low cost, high quality, and short lead-time requirements, have made engineering design a very complex and inter-disciplinary activity. The recent Internet revolutions and stringent environmental concerns further contribute to the complexity of modern engineering design.

To face this great challenge, basic research into the fundamentals of engineering design has been undertaken in various disciplines. Over the past few decades, significant progress has been made, especially in the areas of computer-aided design (CAD) and computer-aided engineering (CAE). CAD stations replaced drawing boards, and physical prototypes are being replaced by digital CAE markups. While it is now possible to completely represent all details of an airplane and accurately simulate behaviors of a complex product on computers, engineering design still remains largely as an ad-hoc process and a practice of art. This is especially true for large, complex mechanical systems that are commonly seen in the aerospace and automotive industries today. Design of large-scale, complex mechanical systems is still one of the most challenging areas of engineering design. For these advanced mechanical design activities, forms (i.e., geometries and materials) and functions must be balanced to meet changing customer needs on the market. Diverse knowledge from different Technology, Organization and People (T.O.P.) sources is always involved, and various Social, Economical and Technological (S.E.T.) factors must be considered together.

In recent years, the focus of engineering design research has been expanded from building CAE/CAD tools to studying design theories and methodologies, with the hope to make engineering design education and practice more systematic and scientific. Despite these major efforts, effective executions of complex engineering product designs are still regarded more as an acquired art than an understood science. One of the reasons for this slow progress is a lack of deep understanding of, and common agreement on the questions, "what is engineering design" and "what is good design thinking". Two recent product development trends, namely increased life-cycle concerns and globalization of markets, have further challenged the conventional views of engineering design. On one hand, the desire to incorporate all life cycle concerns of product necessitates a stronger coupling and favors co-location of design teams. On the other hand, market globalization suggests that various stakeholders of design projects should be decoupled and distributed around the world in order to be close to local markets. This disparity between functionally coupled and geographically decoupled design activities leads to the current research focus on collaborative engineering design. The endless possibilities from the Internet revolution have made this new research focus a very exciting area of study that can open up a new frontier of engineering design research.

This course will prepare you with the necessary foundations and practices to face these challenges of engineering design, and become a good design thinker who will be able to choose design targets rationally and solve design problems optimally.

Course Background, Objective and Scope:

In a typical undergraduate engineering design curriculum, main focuses are often placed on using physics-based engineering knowledge to perform technical analyses to support the evaluations of mechanical components design. Some advanced-level undergraduate courses (such as AME410) briefly discuss design theories and methodologies, with emphases on specific systematic 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 AME department and a program required course of the Master of Science in Product Development Engineering (MSPDE) degree, the main goal of AME503 - Advanced Mechanical Design (or it can be more appropriately called: Advanced Topics in Mechanical Systems Design, with a special focus on new product development) is to bridge 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. Following a top-down and synthesis-based design thinking approach, 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 AME503, 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, AME503 is a critical transition from the undergraduate-level bottom-up analysis-based components design to the graduate-level top-down synthesis-based systems design. It should help students’ careers in both design practice and design research in advanced engineering systems design.

The scope of this course is broadly represented by the following three topical areas:

1. **Part I:** Engineering Design: Definitions, Challenges, and Models (Lecture 1-3)
 - What is engineering design and how does it relate to new product development?
 - What are the roles of Design Thinking in engineering design?
 - How to identify customer needs (CN) and innovative functional requirements (FR)?
2. **Part II:** The Axiomatic Design (AD) Approach (Lecture 4-5)
 - Complexity in engineering design – making design simple
 - Axiomatic framework and design process
 - The two basic design axioms – independence and information
 - 1st team design presentation: chosen design targets and initial design concepts using Axiomatic Design theory (Lecture 6)
3. **Part III:** The Inventive Problem Solving (TRIZ) Method in Design (Lecture 7-9)
 - Principles of ideal design in TRIZ
 - The TRIZ framework and process, and it can be used to enhance design concepts
 - Contradiction and evolution in TRIZ
 - 2nd team design presentation: improved design concepts using TRIZ (Lecture 10)

Course Learning Components:

There are three inter-related learning components in this graduate course:

- **Classroom Lectures**

Weekly lectures on Monday and Wednesday afternoons will focus on discussions of advanced subjects in engineering design and product development as listed in the Course Background, Objective and Scope section above. Specific lecture topics can be found in the Course Schedule section of this syllabus. The instructor will develop his own lecture notes in the form of PowerPoint slides, drawn from research papers and reference books. No textbook is required for this graduate course. Additional reading assignments from relevant research papers will be given whenever appropriate. Students are expected to read these assignments as a “preview” for the lectures.

Off-campus (DEN) students are encouraged to watch the live web castings of classroom lectures whenever possible through the DEN webcast systems. Live lectures are always recorded for later reviews by all students. Off-campus students are encouraged to phone in for questions/discussions during the live lecture period, and, if equipped with a desktop web camera, choose to participate in the question/answer with two-way live video via the WebEx system. For technical questions regarding remote lecture/question participations, off-campus students should consult with DEN technical staff directly.

- **Research Paper Studies**

Studying the state-of-the-art research papers in the relevant technical fields is an important means of learning in a graduate-level course. Two (2) technical papers, selected from the wide areas of new product development process and/or design theory and methodology, will be assigned to the class. Students are required to study these papers and write summary reports, showing their understanding of the content and its relevance to the course subjects. Students are encouraged to reference those design theories, processes and technologies discussed in classroom lectures. Specific paper handouts and due dates can be found in the Course Schedule of this syllabus. A specific Discussion Board will be created on the course website for each assigned paper study. In addition to paper study reports, all students are encouraged to post their inputs, opinions and suggestions of the paper onto this Discussion Board before and after the due date of the written reports.

- **Team Design Projects**

The best way to learn engineering design and new product development is to work on a realistic product development project team. Teams with 4-6 students (depending on the final class enrollment number), will be organized to design a new product/system following the product development cycle.

This semester, the AME503 team design projects will focus on innovative conceptual design of “**Computer Input Devices and/or Systems**” to fundamentally revolutionize those conventional computer peripheral products that have remained unchanged over the past few decades. Each design team is required to go through the identification, understanding, and conceptualization stages of new product development to arrive at complete conceptual design specifications of innovative computer input devices and/or systems. Team progresses are to be reported in two (2) design review presentations. The instructor will work with teams closely through the whole semester to identify their design project goals and product concepts.

All AME503 design teams are encouraged to use the DEN virtual meeting systems for their design team meetings. Each team will be assigned a separate “virtual meeting room” on the course website, which only its members (and the Instructor) have access. Members can have interactive audio/video supports when conducting virtual meetings at times of their own choice. Virtual team meeting records will contribute to design team grades.

Office Hours:

Standard office hours are from 1:00pm to 2:30pm, on Mondays. Although on-campus students can come to OHE 400D for face-to-face meetings, all students and teams, whenever possible, are encouraged to experiment with the Skype VoIP system with live audio/video supports for office hour meetings. Group meetings using Skype with the Instructor during office hours are also possible in the same manner. All meetings must have prior appointments and confirmations via emails.

Reading Materials:

Due to the broad scope and diverse subjects that will be discussed in this graduate-level course, no single book can adequately cover them all. Therefore, no required textbook or case study handbook is assigned. Instead, the following reference books are recommended, and periodic handouts, copied from these references, will be given in the class.

Recommended Reference Books (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. *“Creating Breakthrough Products – Innovation from Product Planning to Program Approval”, by Jonathan Cagan and Craig M. Vogel, Financial Times, Prentice Hall.*
4. *“Complexity: Theory and Applications”, Nam P. Suh, Oxford University Press, USA*
5. *“Product Design and Development”, (the third edition), Karl T. Ulrich and Steven D. Eppinger, the McGraw-Hill Companies, Inc.*
6. *“The Design of Things to Come: How Ordinary People Create Extraordinary Products”, Craig M. Vogel, Jonathan Cagan, and Peter Boatwright, Wharton School Publishing.*
7. *“Engineering Design – A Systematic Approach”, G. Pahl and W. Beitz, Springer-Verlag*

8. “*Product Design – Techniques in Reverse Engineering and New Product Development*”, by Kevin Otto and Kristin Wood, Prentice Hall.
9. “Engineering of Creativity – Introduction of TRIZ Methodology of Inventive Problem Solving”, by Semyon D. Savransky, St. Lucie Press, CRC Press Company.
10. “*Step-by-Step QFD – Customer-Driven Product Design*”, by John Terninko, second edition, St. Lucie Press, A CRC Press Company.

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

Course Website:

Students’ learning of this course is supplemented by a specially designed course website on the DEN Blackboard instruction system (<https://www.uscden.net/webapps/login/>). All registered students have access to this website (AME503_20112). The course website structure and contents are implemented to support the specific organization of the course instruction as described in this syllabus. All students should browse around the entire site to familiarize themselves with various areas and functions of this course website.

- Announcements -- important announcements of this course (check it frequently)
- Course Information -- syllabus; information about instructor; how to use this website; etc.
- Lecture Webcasting -- video files of each lecture
- Lecture Slides -- PowerPoint slides of lecture notes
- Paper Studies -- information about your paper studies
- Design Projects -- information about your team design projects
- Additional Readings -- interesting articles that are related to the course subjects
- Resource Links -- external links to websites that have relevant information to the course
- Communication -- all communication tools, including emails and roster
- Discussion Board -- share your thoughts about interesting subjects with the class
- Tools -- Digital Dropbox and other useful functions to manage your course work

Course Grading:

Students will be graded according to the following grading scheme:

- 30% -- two paper study reports (15% each) and Discussion Board participations
- 30% -- final examination (open-book)
- 40% -- design project (a team effort), which consists of:
 - (20%) first design review presentation
 - (20%) second design review presentation

Note that 40% of your semester grade is based on the results of your design project, which is a team effort. All project work done by the team is first given a team grade. This team grade is then weighted for each student, based on confidential team self-evaluations by all team members at the end of the semester according to the following scheme:

Each student will be asked to fill out a questionnaire, which evaluates every team member (including him/herself) for the percentage contribution to the team project in different categories. The evaluations are averaged in order to find each student's contribution and the weighting factor is made proportional to the average. For example, if you have three students on your team and each makes the same (33%) contribution, then all will get the same grade as the team grade. However, if one of your team members makes a 40% contribution, one a 25% contribution, and the third 35% contribution, then the individual grades will be corrected by the difference from 33%. Thus, if the team grade on your project presentation (or filed test, or product development file) is 85%, then the first student would get 92% ($85 + (40-33)$), the second would get 77% ($85 + (25-33)$), and the third 87% ($85 + (35-33)$).

Each of the above grading components is further explained in details below.

Grading Components:

- **Paper Study Reports (30%)**

Two (2) relevant research papers will be assigned for detail readings and comments. For each assigned paper, students will be asked to write a study report up to 5 pages in length, 12 pt, type, typewritten, double-spaced, with maximum 1" margins.

Students are expected to use and reference as much as possible the materials discussed in classroom lectures in developing these paper study reports. Please avoid repeating the content of the paper. Reports are due at the beginning of the class (see the Course Schedule below). Students can turn in paper study reports one week late for 50% of the credit. No credit will be given afterwards.

- **Design Project (40%)**

The class will be organized into six (6) teams of 5-6 students to perform design projects that provide opportunities to exercise knowledge learned from classroom lectures and paper studies. Team formation must be completed by the first class in the second week. Each team will go through the product development phases in a new product development process: Identification, Understanding, and Conceptualization to design new systems, subsystems, components for innovative computer input systems and devices. Teams will report their progresses at two design review presentations (20% of the semester grade, each).

Two (2) Design Review Presentations (total 40%) will be held on June 8th and June 22nd, 2011. Each design team is expected to make a 25-minute informal review presentation of its design results up to that stage to receive comments/questions from the class and approvals from the instructor before proceeding further. As much as practical, off-campus students are expected to come to the campus or call in to join these review presentations. Based on the results and efforts at that phase, a team grade (each 20% of

the semester grade) will be given, and then weighted by the above team-grading scheme for individual grades.

- **Final Examination (30%)**

Final exam is open-book, limited to the materials that have been discussed in classroom lectures, design team projects, and/or paper studies. Questions are open-ended, but are made brief and point specific as much as possible. They often require only short answers that show your comprehension of the concepts, definitions, approaches, and tools covered.

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.

Course Schedule:

A course schedule with specific lecture topics and paper study/design project requirements are included below. The Instructor reserves the right to modify this schedule according to the lecture progresses and class needs.

SUM 2011	Session I: 5:30pm– 6:45pm	Session II: 6:55pm – 8:10pm	Paper Study and Design Project
5/18 (Wed)	Course Overview, Subject Introduction Course Syllabus, and Course Website	Design Thinking – Rationality and Optimality in Engineering Design	Design Team Assembly Begins
5/23 (Mon)	Understand the Emerging Market Trends (Customer Needs: CN)	Understand the Functional Views of Design (Functional Requirements: FR)	Design Team Assembly Completes
5/25 (Wed)	Understand the Emerging Market Trends (Customer Needs: CN)	Understand the Functional Views of Design (Functional Requirements: FR)	1 st Paper Study Assignment (due on 6/8)
5/30 (Mon)	Memorial Day. No class.		
6/1 (Wed)	Axiomatic Design Approach for Conceptual Design FR→DP (1)	Axiomatic Design Approach for Conceptual Design FR→DP (2)	
6/6 (Mon)	Axiomatic Design Approach for Conceptual Design FR→DP (3)	Axiomatic Design Approach for Conceptual Design FR→DP (4)	2 nd Paper Study Assignment (due on 6/22)
6/8 (Wed)	First Team Design Review Presentation (Present the Initial Design Concepts CN→FR→DP via AD)		1 st Paper Study Due
6/13 (Mon)	TRIZ to Improve the Innovativeness of Initial Design Concepts FR←DP (1)	TRIZ to Improve the Innovativeness of Initial Design Concepts FR←DP (2)	1 st Design Presentation Slide Due.
6/15 (Wed)	TRIZ to Improve the Innovativeness of Initial Design Concepts FR←DP (3)	TRIZ to Improve the Innovativeness of Initial Design Concepts FR←DP (4)	
6/20 (Mon)	TRIZ to Improve the Innovativeness of Initial Design Concepts FR←DP (5)	TRIZ to Improve the Innovativeness of Initial Design Concepts FR←DP (6)	
6/22 (Wed)	Second Team Design Review Presentation (Present the Improved Design Concepts FR*→DP* via TRIZ)		2 nd Paper Study Due.
6/27 (Mon)	Final Exam (5:30pm-7:30pm)		2 nd Design Presentation Slide Due.

NOTE: This course was originated by Dr. Stephen Lu (sclu@usc.edu)