Department of Aerospace and Mechanical Engineering

AME 510: Advanced Computational Design and Manufacturing
Units 4
Fall 2025

Course Syllabus

Course General:

The lectures meet on **Wednesday 6:00 - 9:20 pm**.
Location: GFS-223

Course Instructor: Dr. Yong Chen,
Office: OHE-430E
Office Hours: Wednesday 10 am – 12 pm and 1:30 - 3 pm, or by appointment.
Contact Info: Tel: 213-740-7829; Email: yongchen@usc.edu

Teaching Assistant: TBA

Course Description

This course aims to give students a deep understanding and practical experience in applying computational techniques to solve design and manufacturing problems. It will introduce the underlying concepts behind three-dimensional geometry representations, algorithms, and the underlying mathematical foundations, essential to solving a wide variety of problems in computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided engineering (CAE). It will also train the students with hands-on computational skills by working on team-based course projects. Also, the course will prepare the students to read literature, understand current research problems, and identify possible contributions to the field.

This graduate-level course is intended for students who plan to have a career in product development, CAD/CAM/CAE, robotics, manufacturing automation, virtual reality, technology management, entrepreneurship, etc. The course will help students understand the principles behind CAD, CAM, and CAE systems, and develop novel software applications for computational design and manufacturing. The course will also prepare the students to read literature, understand real-world problems, and identify possible future innovations.

The course will consist of four parts: (1) preparation with an introduction, (2) geometric representation of three-dimensional solid objects, (3) basic geometric computation algorithms, and (4) real-world applications of modeling and computation in solving some design and

manufacturing problems such as feature recognition, CNC tool path planning, RP process simulation, and computer-aided inspection, etc. Source codes of a testbed will be given in the class so that students can gain hands-on experience and demonstrate concepts and applications.

Learning Objectives

After completing this course, students will be able to:

- define mathematical foundations for CAD/CAM/CAE systems;
- analyze geometric representations for three-dimensional solid objects;
- devise geometric computation algorithms to solve digital design and manufacturing automation problems;
- select modeling and computation methods for diverse CAD/CAM/CAE applications;
- work in a team to build practical CAD/CAM/CAE systems.

Prerequisites: none

Recommended Preparation: Students are desired to be familiar with programming (C++ or Matlab or others) to gain hands-on experience. Programming (C++ or MATLAB) on the level of ITP 168 (MATLAB), or ITP 165 (C++), or CSCI 102 (C++).

Textbook

- "Principles of CAD/CAM/CAE Systems". K. Lee. Addison Wesley, 1999 (ISBN-13: 978-0201380361).

Additional handouts will be given before classes.

Supplemental References

- Gross, M. and H. Pfister, Point-based Graphics, Morgan Kaufmann Publishers, 2007 (ISBN-13: 978-0123706041).
- Zeid, I., Mastering CAD/CAM, McGraw Hill, 2005 (ISBN-13: 978-0072868456).
- Corney, J. and T. Lim. 3D Modeling with ACIS. Saxe-Coburg Publications, 2001 (ISBN-13: 978-1874672142).
- M. de Berg, et. al. Computational Geometry – Algorithms and Applications. Springer, 2000 (ISBN-13: 978-3540779735).
- Mortenson, M. E. Geometric Modeling. Wiley Computer Publishing, 1997 (ISBN-13: 978-0471129578).
- Shah, J. and M. Mantyla, Parametric and Feature-Based CAD/CAM, John Wiley and Sons, 1995 (ISBN-13: 978-0471002147).

Grading Policy

The first portion of the course grading will include homework assignments and two quizzes. The second portion of the course grading will be based on two class projects students will do over the

semester, i.e., a literature survey project and an application development project. The grading for the class will be determined using the following weights:

- Homework assignments…… 35%
- Quizzes …… 20%
- Literature survey project ……. 15%
- Development project ……..…….. 25%
- Participation…… 5%

Total Score…… 100%

Homework Assignments: Students will be given 1~2 weeks for each homework assignment, consisting of solving problems that correspond to the materials covered in class in the previous weeks. There will be 7 homework assignments. Most homework assignments are hands-on and require using the testbed that will be provided to the students at the beginning of the class. Assignments are due on the date given in the handouts. Submissions will be accepted for credit up to one class period after the due date for 50% credit. There will be no acceptance after one week.

Quizzes: Two quizzes will be given during the semester with notice.

Class projects: The objective of the class projects is to help the students gain hands-on experience and demonstrate the ability to use learned materials to solve real-world problems. Each project team will have 2~3 students who are expected to work together to accomplish tasks. Two class projects will be given over the semester, and the formed project team will be the same for both projects.

(1) In the literature survey project, each team is expected to read 5-8 technical papers in a CAD/CAM/CAE area related to geometric modeling and computation. The students are required to present their findings and write a literature survey paper (15%). Some example survey topics include multi-material design, generative design, automated composite manufacturing, support structures for 3D printing, dental device simulation, etc. Each project team will propose survey topics and discuss them with the instructor to finalize them at the beginning of the literature survey project.

(2) In the application development project, each team is expected to develop an application of geometric modeling and computation techniques to solve a non-trivial CAD/CAM/CAE problem. Possible projects should be agreed upon with the professor by submitting a formal project proposal. The final project should be done with a demonstration and a technical report (25%). Some example development project topics include customized shoe sole design, robotic gripper optimization, chocolate 3D printing, automated filament deposition system, tetrahedral mesh modeling, etc. Each project team will propose ideas and discuss them with the instructor to finalize the project topic at the beginning of the application development project.

Each project team must prepare a conference-style presentation to explain their ideas, methods, and results to the class. Presentations should take about 20 minutes, and the presenters should be prepared to answer questions on the topic (in an additional 5 minutes Q&A). Each project

team must submit a project report. The project report requirements will be discussed in the class, and sample project reports will be provided in Brightspace. Both the presentation and project report will be used in the evaluation.

Participation: Participation in the class is required. Random roster calls will be made over the semester to determine the participation. In-class demonstrations of the lab assignments will be organized. Bonus points are available for enthusiastic participation in class. If you miss a class, please work with your fellow students to catch up on what you missed. Please turn cell phones off or put them in vibrate mode before coming to class.

Tentative Course Schedule

Week	Topics	Assignments	Readings / Projects
Introduction and Background			
1 (Aug. 27)	• Course Overview • Discussion of C++ and Matlab programming • Programming environment and testbed • CAD/CAM/CAE Overview	HW1 assigned	Self-study on related prerequisites
2 (Sept. 3)	• Geometric Transformations • Mathematica and geometric tools • Literature survey project	HW2 assigned	- Form project teams - The literature review project assigned with topics suggested.
Representations and Mathematical Models			
3 (Sept. 10)	• Boundary Representations of Solids • Meshes & STL • Mesh slicing for 3D printing	HW3 assigned	Literature review topic due.
4 (Sept. 17)	• Half-edge representation • Finite element analysis (FEA) and tetrahedron • An introduction of Altair Inspire and a topology optimization test case	HW4 assigned	
5 (Sept. 24)	• Decomposition Representations of Solids • Layered Depth-Normal Images • Sampling points and 3D scanning • Design for additive manufacturing		
6 (Oct. 1)	• Hermite, Bezier, and B-Spline Curves • Hermite, Bezier, and B-Spline Surfaces • Curve-based tool path planning	HW5 assigned	
Geometric Computation Methods and Algorithms			
7 (Oct. 8)	• **Quiz 1** • Application development project • Point and vector		The application development project assigned

	• Vector and volume calculation		with topics suggested.
8 (Oct. 15)	• Vector operators • Automatic support generation in 3D printing • Support volume Calculating	HW6 assigned	
9 (Oct. 22)	• **Literature review presentation** (25 minutes/team) • Application development project discussion • Set operations • Boolean operators • Fast Boolean operation based on LDNI		- Literature review report due
10 (Oct. 29)	• Euler operators • Other Computations • Automatic shape generation • Topology optimization • Generative design for additive manufacturing	HW7 assigned	- Application development project topic due.
Applications in CAD/CAM/CAE			
11 (Nov. 5)	• **Quiz 2** • CAD: Automatic design for injection molding and die-casting		
12 (Nov. 12)	• CAE: 2D Delaunay Triangulation for Reverse Engineering and Finite Element Analysis • Delaunay-based shape generation and slicing • Application development project discussion		
13 (Nov. 19)	• CAM: Manufacturing process planning: machining and 3D printing, adaptive slicing, and build orientation optimization • Application development project discussion		
14 (Nov. 26)	• **Thanksgiving break** (no class)		
15 (Dec. 3)	• **Application development project presentation of methods and implementations** (~25 minutes/team) • Course Review & Evaluation		
Final (Dec. 10)	(Final Exam Date - Refer to the final exam schedule in the USC Schedule of Classes at www.usc.edu/soc) Dec. 7-9 pm • **Application development project demonstration of functional prototype systems** (~20 minutes/team)		Application development project report due.

Statement on Academic Conduct and Support Systems

Academic integrity:
The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission

of ideas. Academic misconduct contrasts with the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form). This course will follow the expectations for academic integrity as stated in the USC Student Handbook. All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Course Content Distribution and Synchronous Session Recordings Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. (Living our Unifying Values: The USC Student Handbook, page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relationship to the class, whether obtained in class, via email, on the internet, or via any other media. (Living our Unifying Values: The USC Student Handbook, page 13).

Statement on Academic Conduct and Support Systems

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

988 Suicide and Crisis Lifeline - 988 for both calls and text messages – 24/7 on call
The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL) – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention - (213) 740-0411
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity, Equity and Inclusion - (213) 740-2101
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call
Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - (323) 442-2850 or otfp@med.usc.edu
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.