

University of Southern California  
Daniel J. Epstein Department of Industrial and Systems Engineering

ISE 510: Advanced Computational Design and Manufacturing

Course Syllabus

**Course Instructor:**

Dr. Yong Chen, GER-201

Tel: 213-740-7829, Email: yongchen@usc.edu

Office Hours: Wednesday from 2:00 to 3:30pm or by appointment.

**Course General:**

The course meets Monday from 6:30 to 9:10 pm. Location TBA

**Course Description:**

This course aims to provide students with deep understanding and practical experience in the application of 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. In addition, the course will prepare the students to read literature, understand current research problems, and identify possible contributions to the field.

This is a graduate level course and intended for students who plan to have a career in CAD/CAM/CAE, robotics, design and manufacturing automation, virtual reality, and computer graphics areas. This course will also help students in understanding the principles behind CAD, CAM and CAE systems, and developing novel software applications.

The course will consist of three parts: (1) geometric representation of three-dimensional solid objects, (2) basic geometric computation algorithms, and (3) 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 for students to gain hands-on experience. A geometric modeling kernel (ACIS) will also be used to demonstrate concepts and applications.

**Prerequisites:**

No formal prerequisites. The material and assignments will assume students are familiar and comfortable with programming (C++ preferred).

**Textbook**

*"Principles of CAD/CAM/CAE Systems"*. K. Lee. Addison Wesley, 1999.

Additional handouts will be given in the class.

## References

- Zeid, I., *Mastering CAD/CAM*, McGraw Hill, 2005.
- Corney, J. and T. Lim. *3D Modeling with ACIS*. Saxe-Coburg Publications, 2001.
- Shah, J. and M. Mantyla, *Parametric and Feature-Based CAD/CAM*, John Wiley and Sons, 1995.
- Hoffmann, C. M. *Geometric and Solid Modeling*. Morgan Kaufman Publishers, 1989.
- Mantyla, M.. *Introduction to Solid Modeling*. Computer Science Press, 1988.
- Mortenson, M. E. *Geometric Modeling*. Wiley Computer Publishing, 1997.
- M. de Berg, et. al. *Computational Geometry – Algorithms and Applications*. Springer, 2000.

## Grading Policy:

The first part of the course will include problem assignments and will be capped into a midterm exam. In the second part of the course students will be required to do two class projects, a literature survey project and an application development project. The grading for the class will be determined using the following weights:

- Problem assignments..... 20%
- Midterm.....25%
- Literature survey project .....20%
- Development project .....30%
- Participation..... 5%
- Total Score.....100%

Problem Assignments: Students will be given 2~3 weeks for each assignment, which will consist of solving problems that correspond to the materials covered in class in the previous weeks.

Midterm Exam: One examination will be given in the middle of the semester.

Class projects: The objective of the class projects is to help the students to gain hands-on experience and 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.

- (1) In the literature survey project, each team is expected to read 5-8 technical papers in a CAD/CAM area related to geometric modeling and computation. The students are required to present their findings and write a literature survey paper (20%);
- (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 problem. Possible projects should be agreed with the professor with a formal project proposal. The final project should be done with a demonstration and a technical report.

Each project team must prepare a conference style presentation to explain their ideas, methods and results to the class. Presentations should take about 15 minutes and the presenters should be prepared to answer questions on the topic. The presentation and project report will be used in evaluation.

Participation: Participation in the class is required and will be taken into account. 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 and pagers off or put them in vibrate mode before coming to class.

**Academic integrity:** “The Department of Industrial and Systems 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.”

**Disability Accommodation:**

“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.”

**Tentative Course Schedule:**

Week #	Topic	Assignment
	<b>Introduction and Background</b>	
1	<ul style="list-style-type: none"> <li>• Course Overview</li> <li>• C++, OpenGL, etc.</li> <li>• Programming environment and testbed</li> </ul>	- HW1: Familiar with a testbed given by the instructor
2	<ul style="list-style-type: none"> <li>• Geometric Transformations</li> </ul>	- HW2: Add program in the testbed to implement geometric transformation operators
	<b>Representations and Mathematical Models</b>	
3	<ul style="list-style-type: none"> <li>• Boundary Representations of Solids</li> <li>• Constructive Representations of Solids</li> </ul>	- HW3: Add program in the testbed to implement query of geometry elements
4	<ul style="list-style-type: none"> <li>• Hermite, Bezier, and B-Spline Curves</li> <li>• Hermite, Bezier, and B-Spline Surfaces</li> </ul>	Literature review project assigned.
5	<ul style="list-style-type: none"> <li>• Point Set Based Mathematical Models of Solids</li> <li>• Decompositional Representations of Solids</li> </ul>	- HW4: Add program in the testbed to calculate model properties
6	<ul style="list-style-type: none"> <li>• Feature-Based and Parametric Representations of solids</li> <li>• Other Representations</li> </ul>	
	<b>Basic Geometric Computation Algorithms</b>	
7	<ul style="list-style-type: none"> <li>• Vector and volume calculation</li> </ul>	- HW5: Add program in the testbed to find the best direction of a model for maximum visibility

8	<ul style="list-style-type: none"> <li>• Polygon Triangulation</li> </ul>	Application development project assigned.
9	<ul style="list-style-type: none"> <li>• Euler and Boolean operators</li> </ul>	- HW6: Write an ACIS program to do Boolean operations of two models.
10	<ul style="list-style-type: none"> <li>• 2D Delaunay Triangulation</li> <li>• Mesh Generation</li> </ul>	Literature review report due.
11	Mid-term Exam	
	<b>Applications in CAD/CAM/CAE</b>	
12	<ul style="list-style-type: none"> <li>• Rapid tooling feature recognition</li> </ul>	
13	<ul style="list-style-type: none"> <li>• RP process planning</li> </ul>	
14	<ul style="list-style-type: none"> <li>• CNC tool path generation</li> </ul>	
15	<ul style="list-style-type: none"> <li>• Design for direct digital manufacturing</li> </ul>	
16	<ul style="list-style-type: none"> <li>• Reverse engineering and part inspection</li> </ul>	
17	<b>Final project presentation</b> (final exam date)	Application development project due.