

University of Southern California  
Daniel J. Epstein Department of Industrial and Systems Engineering  
ISE 510 / AME 510: Advanced Computational Design and Manufacturing  
Class Number 31512D, Units 3  
Spring 2021

**Course Syllabus**

**Course General:**

The course meets on Thursday 6:30 ~ 9:10 pm at LVL-13 & online.

**Course Instructor:**

Dr. Yong Chen, GER-201

Tel: 213-740-7829, Email: [yongchen@usc.edu](mailto:yongchen@usc.edu)

Office Hours: Thursday (2-5pm) or by appointment.

**Teaching Assistant:**

Mr. Yang Xu, Tel: 213-245-0684, Email: [yxu195@usc.edu](mailto:yxu195@usc.edu)

Office Hours: Thursday 2:30-5:30 pm or by appointment, GER-242.

**Course Description:**

This course aims to provide students with a 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. Also, the course will prepare the students to read literature, understand current research problems, and identify possible contributions to the field.

This course is a graduate level course that is intended for students who plan to have a career in areas of product development, CAD/CAM/CAE, robotics, manufacturing automation, virtual reality, technology management, entrepreneurship, etc. The 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 four parts: (1) preparation with 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 for students to gain hands-on experience, and to demonstrate concepts and applications.

**Prerequisites:**

No formal prerequisites. Students are desired to be familiar to certain programming (C++ or Matlab) to gain hands-on experience.

## Suggested Textbook

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

Additional handouts will be given before classes.

## References

- Gross, M. and H. Pfister, *Point-based Graphics*, Morgan Kaufmann Publishers, 2007.
- Zeid, I., *Mastering CAD/CAM*, McGraw Hill, 2005.
- Corney, J. and T. Lim. *3D Modeling with ACIS*. Saxe-Coburg Publications, 2001.
- M. de Berg, et. al. *Computational Geometry – Algorithms and Applications*. Springer, 2000.
- Mortenson, M. E. *Geometric Modeling*. Wiley Computer Publishing, 1997.
- 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.

## Grading Policy:

The first portion of the course grading will include problem assignments and two quizzes. The second portion of the course grading will be based on two class projects that 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:

- Problem assignments..... 35%
- Quizzes .....20%
- Literature survey project .....15%
- Development project .....25%
- Participation..... 5%
- Total Score.....100%

Problem Assignments: Students will be given 1~2 weeks for each assignment, which will consist of solving problems that correspond to the materials covered in class in the previous weeks. Most assignments are hands-on and required to use the testbed that will be provided to the students in the beginning of the class. Assignments are due on the date given in the handouts. Submission 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 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/CAE area related to geometric modeling and computation. The students are required to present their findings and write a literature survey paper (15%);
- (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 with the professor with a formal project

proposal. The final project should be done with a demonstration and a technical report (25%).

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 the 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.

#### Tentative Course Schedule:

Week #	Topic	Assignment	Reading / Project
1	<b>Introduction and Background</b> (Jan. 21) <ul style="list-style-type: none"> <li>• Course Overview</li> <li>• Matlab and C++ programming</li> <li>• Programming environment and testbed</li> <li>• CAD/CAM/CAE Overview</li> </ul>	HW1	Self-study on related prerequisites
2	(Jan. 28) <ul style="list-style-type: none"> <li>• Geometric Transformations</li> <li>• Literature survey project</li> </ul>	HW2	- Form project teams (2 students/team) - Paper review project assigned with topics suggested.
3	<b>Representations and Mathematical Models</b> (Feb. 4) <ul style="list-style-type: none"> <li>• Boundary Representations of Solids</li> <li>• Meshes &amp; STL</li> </ul>	HW3	Paper review topic due.
4	(Feb. 11) <ul style="list-style-type: none"> <li>• Half-edge representation</li> <li>• FEA and tetrahedron</li> </ul>	HW4	
5	(Feb. 18) <ul style="list-style-type: none"> <li>• Decomposition Representations of Solids</li> <li>• Layered Depth-Normal Images</li> <li>• Topology optimization and design for additive manufacturing</li> </ul>		

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| 6   | (Feb. 25)  | HW5   |
|   | <ul style="list-style-type: none"> <li>• Hermite, Bezier, and B-Spline Curves</li> <li>• Hermite, Bezier, and B-Spline Surfaces</li> </ul>   |   |
| 7   | (Mar. 4)   | Application development project assigned with topics suggested. |
|   | <ul style="list-style-type: none"> <li>• <b>Quiz 1</b></li> <li>• Application development project</li> </ul>   |   |
| <b>Geometric Computation Methods and Algorithms</b> |  |   |
| 8   | (Mar. 11)  | - Paper review report due                                       |
|   | <ul style="list-style-type: none"> <li>• <b>Paper review presentation</b> (25 minutes/team)</li> <li>• Point and vector</li> </ul>   |   |
| 9   | (Mar. 18)  | HW6   |
|   | <ul style="list-style-type: none"> <li>• Vector and volume calculation</li> <li>• Vector operators</li> <li>• Application development project discussion</li> </ul>                                      |   |
| 10  | (Mar. 25)  | - Application development project topic due.                    |
|   | <ul style="list-style-type: none"> <li>• Set operations</li> <li>• Boolean operators</li> <li>• Fast Boolean operation based on LDNI</li> <li>• Euler operators</li> <li>• Other Computations</li> </ul> |   |
| <b>Applications in CAD/CAM/CAE</b>                  |  |   |
| 11  | (Apr. 1)   |   |
|   | <ul style="list-style-type: none"> <li>• <b>Quiz 2</b></li> <li>• <u>CAD</u>: Automatic design for injection molding</li> </ul>  |   |
| 12  | (Apr. 8)   |   |
|   | <ul style="list-style-type: none"> <li>• <u>CAE</u>: 2D Delaunay Triangulation for Reverse Engineering and Finite Element Analysis</li> <li>• Application development project discussion</li> </ul>      |   |
| 13  | (Apr. 15)  |   |
|   | <ul style="list-style-type: none"> <li>• <u>CAM</u>: Manufacturing process planning: machining and 3D printing</li> </ul>  |   |
| 14  | (Apr. 22)  |   |
|   | <ul style="list-style-type: none"> <li>• <b>Wellness day (no class)</b></li> </ul>   |   |

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| 15 | (Apr. 29)                         | <ul style="list-style-type: none"> <li>• <b>Application development project presentation</b><br/>(20 minutes/team)</li> <li>• Course Review &amp; Evaluation</li> </ul> |   |
| 16 | (May. 6: 7-9pm - Final Exam Date) | <ul style="list-style-type: none"> <li>• <b>Application development project demonstration</b><br/>(20 minutes/team)</li> </ul>  | Application development project report due. |
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**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.”

**Statement on Academic Conduct and Support Systems**

**Academic Conduct:**

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, “Behavior Violating University Standards” [policy.usc.edu/scampus-part-b](http://policy.usc.edu/scampus-part-b). Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, [policy.usc.edu/scientific-misconduct](http://policy.usc.edu/scientific-misconduct).

**Support Systems:**

*Student Health Counseling Services - (213) 740-7711 – 24/7 on call*

[engemannshc.usc.edu/counseling](http://engemannshc.usc.edu/counseling)

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

*National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call*

[suicidepreventionlifeline.org](http://suicidepreventionlifeline.org)

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

*Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 – 24/7 on call*

[engemannshc.usc.edu/rsvp](http://engemannshc.usc.edu/rsvp)

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

*Office of Equity and Diversity (OED) | Title IX - (213) 740-5086*

[equity.usc.edu](http://equity.usc.edu), [titleix.usc.edu](http://titleix.usc.edu)

Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

*Bias Assessment Response and Support - (213) 740-2421*

[studentaffairs.usc.edu/bias-assessment-response-support](http://studentaffairs.usc.edu/bias-assessment-response-support)

Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

*The Office of Disability Services and Programs - (213) 740-0776*

[dsp.usc.edu](http://dsp.usc.edu)

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

*USC Support and Advocacy - (213) 821-4710*

[studentaffairs.usc.edu/ssa](http://studentaffairs.usc.edu/ssa)

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

*Diversity at USC - (213) 740-2101*

[diversity.usc.edu](http://diversity.usc.edu)

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*

[dps.usc.edu](http://dps.usc.edu), [emergency.usc.edu](http://emergency.usc.edu)

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) 442-120 – 24/7 on call*

[dps.usc.edu](http://dps.usc.edu)

Non-emergency assistance or information.