ME 397/379M Solid Freeform Fabrication

Mechanical Engineering Department, The University of Texas at Austin
Spring 2009, TTh 9:30 – 11 AM, ETC 4.150

Instructor

Carolyn Conner Seepersad
Office: ETC 4.138, Phone: 471-1985, Email: ccseepersad@mail.utexas.edu
Office Hours: TTh 11 – 12:30 PM, or by appointment

Course Description and Goals

Solid freeform fabrication (SFF) is the use of additive manufacturing processes for producing parts directly from computer (CAD) models, without part-specific tooling. Rapid manufacturing is the use of SFF for realizing functional parts. In this course, students will learn about a variety of SFF technologies, their potential to support rapid prototyping and manufacturing, and some of the important research challenges associated with SFF.

Upon completion of this course, each student should be able to:

- Identify appropriate applications for solid freeform fabrication.
- Explain the capabilities, limitations, and basic principles of alternative SFF technologies; and evaluate and select appropriate SFF technologies for specific design-manufacturing applications.
- Explain the fundamental causes of errors and irregularities in SFF parts, with a focus on selective laser sintering (SLS).
- Apply rapid prototyping techniques to a challenging rapid manufacturing application.
- Identify, explain, and prioritize some of the important research challenges in SFF.

Topics

(1) Introduction to Solid Freeform Fabrication (2 lectures)
- Overview and History of SFF
- Interesting Applications of SFF
- SFF Process Chain

(2) Alternative Technologies for Solid Freeform Fabrication (6 lectures)
- Liquid-Based Systems (Stereolithography)
- Solid-Based Systems (Fused Deposition Modeling, Laminated Object Manufacturing, Ultrasonic Consolidation, Contour Crafting, Polyjet)
- Powder-Based Systems (Selective Laser Sintering, 3D Printing, Laser Engineered Net Shaping, Electron Beam Melting)

(3) Selection of Solid Freeform Fabrication Technologies (2 lectures)
- Selection Decision-Making
- Evaluation Criteria for SFF

(4) An In-Depth Look at Selective Laser Sintering (6 lectures)
- Sintering Kinetics
- Process Models
- Commercial Part/Process Inaccuracies

(5) Design for Solid Freeform Fabrication (and Rapid Manufacturing) (6 lectures)
- Identifying SFF Opportunities (Economics of SFF, Customer Needs Analysis)

- Design for SFF (Design Freedom, Customization, Optimization, Compressed Design Cycles, and "Manufacture for Design")
- Evaluating Prototypes and Products

(6) Guest lectures and field trips TBA (3 lectures)
(7) Student presentations (3 lectures)

Grading

		Total
Design Project		50%
Project Proposal	10%	
Final Project Report	35%	
Final Project Presentation	5%	
Assignments		40%
Attendance, participation, peer evaluations, etc		10%
		100%

Textbook

The recommended textbook for the course is the following:

- Chua, C. K., K. F. Leong and C. S. Lim, 2003, *Rapid Prototyping: Principles and Applications,* World Scientific, River Edge, NJ. (Available at amazon.com for less than $45 in the paperback version.)

Additional References

The following resources are recommended. They are on reserve in the Engineering Library.

- Hopkinson, N., R. Hague and P. Dickens, Eds., 2006, *Rapid Manufacturing: An Industrial Revolution for the Digital Age*, John Wiley, New York.
- *Proceedings of the Solid Freeform Fabrication Symposium,* (Beaman, Bourell, Crawford, Marcus, Seepersad, Wood, Eds.), The University of Texas at Austin, Austin, Texas. (1990 – 2008)
- Beaman, J. J., J. W. Barlow, D. L. Bourell, R. H. Crawford, H. L. Marcus and K. P. McAlea, 1997, *Solid Freeform Fabrication: A New Direction in Manufacturing,* Kluwer Academic Publishers, Boston.
- Liou, F., 2008, *Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development,* CRC Press, Boca Raton, FL.
- Gebhardt, A., 2003, *Rapid Prototyping,* Hanser Publishers, Munich.
- McDonald, J. A., C. J. Ryall and D. I. Wimpenny, Eds., 2001, *Rapid Prototyping Casebook*, Professional Engineering Publishing, London.
- Kamrani, A. K. and E. A. Nasr, 2006, *Rapid Prototyping: Theory and Practice,* Springer, New York, NY.
- Gibson, I., Ed., 2005, *Advanced Manufacturing Technology for Medical Applications: Reverse Engineering, Software Conversion and Rapid Prototyping*, John Wiley & Sons, Chichester, UK.

Additional references may be recommended in class. (All additional recommended/required references will be available in the library or on the internet.)

Project, Assignments, Design Journal, and Related Items

Project. Students will form groups of 4-5 and apply topics learned in the course to a rapid manufacturing design project. Each group will identify an opportunity for rapid manufacturing (i.e., the use of SFF to fabricate a functional part/product), clarify the task, generate concepts, analyze and refine a promising concept, and fabricate it with selective laser sintering. Assistive devices and other individually customized products are promising categories for candidate products. Students are encouraged to pick

projects based on their own interests, and the instructor will be available for advice on project selection and scoping. Projects are evaluated based on a project proposal, final project report, and final project presentation. The final project report and presentation will be *in a form suitable for a peer-reviewed journal or conference paper and presentation*; it is anticipated that some of the projects will lead to such publications. *Students will gain significant experience with writing and presenting research suitable for a technical audience.*

Assignments. Four homeworks will be assigned. Details will be provided in class. The final homework assignment will require a critical evaluation of course topics.

Attendance, Participation, Peer Evaluations. Attendance in class is mandatory and monitored with periodic roll calls. Notify the instructor **in advance** if you must be absent for a legitimate reason. The instructor also monitors your participation in class and includes this assessment in your final grade, along with the results of peer evaluations of your participation in team project activities.

Deadlines and Penalties. *All assignments must be submitted on time.* Assignments are due before the beginning of class on the designated day. Unless prior approval is obtained from the instructor, late assignments will be penalized 10% or one letter grade *per day*.

Prerequisites

Admission to major sequence in mechanical engineering or graduate standing in engineering or related discipline. Students should be familiar with the following topics at an ***undergraduate*** level:

- design methodology. Students should be able to identify and implement the major phases of task clarification, conceptual design, and embodiment/detail design.
- engineering science. To complete their projects, students will benefit from familiarity with two or more major subject areas, such as thermal/fluid systems, solid mechanics, dynamic systems and controls, materials science, electrical systems, or manufacturing.
- computer-aided design and computer aided engineering.
- statistics and calculus through partial differential equations.

Adding/Dropping the Course

An engineering student must have the Dean's approval to add or drop a course after the fourth class day of the semester or after the second class day of a summer term. Adds/Drops are not approved after the fourth class day, except for a good cause such as documented evidence of an extenuating non-academic circumstance (e.g., health or personal problems) that did not exist on or before the fourth class day. Applications for approval to drop a course after the fourth class day should be made in the Office of Student Affairs, ECJ 2.200.

Course/Instructor Evaluation

All students will have the opportunity to evaluate the course and instructor using the standard MEC (Management and Evaluation Center) form during the last week of classes. An intermediate survey will also be conducted by the instructor during the semester. Constructive feedback is encouraged at any time via personal discussions or email.

Academic Integrity

Academic dishonesty will not be tolerated in this course. Penalties are likely to include a grade of F for the activity and/or for the course. Ask your instructor if you have any questions about expectations for a particular activity. You are encouraged to discuss any aspect of the course with classmates and project team members, but remember the following rules:

- Do not plagiarize the work of others by copying from the web, other students, previous students, articles, or other sources (aside from compiling work from your teammates for group project activities) without properly referencing your sources.

Blackboard

The instructor will post lecture slides, assignments, and other handouts and interesting links on the blackboard web site. Please logon at http://courses.utexas.edu. The web site is password-protected. Site activities will include exchanging email, engaging in class discussions and chats, and exchanging files. In addition, electronic class rosters will be a component of the site. Students who do not want their names included in these electronic class rosters must restrict their directory information in the Office of the Registrar, Main Building, Room 1.

Special Needs

The University of Texas at Austin provides upon request appropriate academic adjustments for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-4641 TDD or the College of Engineering Director of Students with Disabilities at 471-4321.