ME 4644 Introduction to Rapid Prototyping
ME 5644 Rapid Prototyping

Fall 2006 — CRN 93920 (ME 4644), 93929 (ME 5644)

CLASS MEETINGS: Mondays / Wednesdays • 2:30-3:45PM • 206 Randolph Hall

The VT CAD Laboratory is reserved for your optional use on Fridays 2:30-3:45PM.

Occasionally, the Friday 2:30-3:45PM timeslot will be used to make up cancelled classes.

Audience

Students interested in exploring recent advances in rapid prototyping and automated fabrication. ME 4644 is approved as an ME technical elective, but it is not approved for graduate credit. ME 5644 carries graduate credit. These two courses meet at the same time and in the same location, and their content overlap substantially. Students may therefore not receive credit for both ME 4644 and ME 5644, even if taken during different semesters.

Instructor

Dr. Jan Helge Bøhn

Office:	114-H Randolph Hall (inside the VT CAD lab)
Office Hours:	MW 1:00-2:00PM, and by appointment.
E-mail:	**bohn@vt.edu**
Telephone:	231-3276 (in emergency: 951-2080 [home], 540-257-3558 [mobile])
Course WWW:	**http://www.cadlab.vt.edu/ME4644/**

Co-requisite

- ME 4634 *Introduction to Computer Aided Design and Manufacturing,* or the equivalent experience in computer aided design.
- Programming skills is useful but not required: C or C++ is preferred; FORTRAN or MATLAB will suffice.

Textbooks, Equipment, Materials, and Supplies

- **REQUIRED:**

  Rafiq Noorani, *Rapid Prototyping: Principles and Applications*, John Wiley & Sons, Inc., 2006, ISBN 0-471-73001-7

  Other required reading assignments that are provided online

- **OPTIONAL:**

  Ian Gibson (ed.), *Advanced Manufacturing Technology for Medical Applications*, John Wiley & Sons, Ltd., 2005, ISBN 0-470-01688-4

  Other optional reading assignments will be available in the VT Newman Library

- **GE Engineering Thermoplastics DESIGN GUIDE.** This document is available online at the course WWW site. Additionally, students have in the past requested free paper copies from GE by calling 1-800-845-0600. Seven such printed copies are available for use in the VT CAD Laboratory.
- **Caliper with 0.001" resolution.** EXAMPLE: Harbor Freight Tools (tel. 1-800-423-2567) offers a 6" digital caliper for $15.99 (item 47257-5VGA) plus $7.99 shipping & handling. Note that the online prices may differ from the catalog and/or telephone prices. The prices shown above were sampled on August 21, 2006 from **http://www.harborfreight.com/**
- Other materials and supplies required as to complete the assignments.
- Additional readings as assigned in class.

Format

This is a three-credit hour course consisting of two 1.5 lecture-hours per week. Grades are based on a midterm and a final exam, and several homework assignments. Self-scheduled VT CAD laboratory, RP laboratory, and (if necessary) ME professional shop and/or ME student shop time will be required to complete the homework assignments.

Students will reverse engineer computer tomography (CT) data into a sculptured solid model and then CNC machine it to produce a physical replica. This will require the use of the NX (and/or I-DEAS) CAD/CAM/CAE system in the Virginia Tech Computer Aided Design Laboratory.

Students will complete two design-fabrication iterations of the housing for an electric razor, subject to aesthetics, human factors, injection molding, and UL standards, using the CAD and rapid prototyping systems of their choice. The Virginia Tech Computer Aided Design Laboratory provides access to NX, I-DEAS, Pro/ENGINEER, and CATIA, and the Department of Mechanical Engineering provides access to a fused deposition modeling (FDM) rapid prototyping system or, alternatively via the Department of Industrial and Systems Engineering, a selective laser sintering (SLS) system). If time permits, the students will also replicate one or more of their prototype parts using RTV silicone rubber molding.

ME 5644 only: Students will investigate a topic related to the latest advances in rapid prototyping, rapid tooling, and their applications, and present their findings to the combined ME 4644 / 5644 class in written and oral form.

The use of the Virginia Tech Writing Center for written assignments is strongly encouraged:
340 Shanks Hall, 231-5436, Monday through Friday, 10 am - 5 pm

Catalog Description

Participants will study topics fundamental to rapid prototyping and automated fabrication, including the generation of suitable CAD models, current rapid prototyping fabrication technologies, their underlying material science, the use of secondary processing, and the impact of these technologies on society. The rapid prototyping process will be illustrated by the actual design and fabrication of a part.

Major, Measurable Learning Objectives

Having successfully passed this course, the student will be able to demonstrate mastery in the majority of each of the following areas:

1. Describe the current available rapid prototyping systems, their fundamental operating principles, and their characteristics;
2. Describe complementary, secondary fabrication processes commonly used with the above rapid prototyping systems; and
3. Select the appropriate fabrication technology, or technologies, for a given prototyping task.

Topical Outline

1. Overview of rapid prototyping and automated fabrication technologies (15%)
   - What is a prototype?
   - Why make a prototype?
   - What is automated fabrication?
   - History of numerical control
   - Process planning; manual, variant, generative
2. Introduction to injection molding (10%)
   - Introduction to injection molding
   - Design for injection molding
   - Selecting materials
   - UL standards
3. Rapid prototyping technologies (20%)
   - Machine tool motion
   - History of layered manufacturing
   - Stereolithography
   - Solid ground curing
   - Selective laser sintering
   - Fused deposition modeling
   - Laminated object manufacturing
   - Other systems
4. The underlying material science (15%)
   - Photopolymers
   - Thermoplastics
   - Powders
5. Generating CAD models suitable for automated fabrication (20%)
   - The .STL file format
   - Repairing CAD models
   - Adding support structures
   - Model slicing
6. Secondary processing (15%)
   - RTV silicone rubber molds
   - Investment casting
   - Improving the quality of prototyping
   - Improving the productivity in manufacturing
   - Medical applications
7. The future (5%)
   - Remote manufacturing on demand
   - Ongoing research activities
   - How can these technologies be improved?

TOTAL 100%

Grading Policy

			TENTATIVE DUE DATES:
Homework	55%	6%	Two sets of CNC machining computer simulations (individual)
		6%	Two sets of FDM computer simulations (individual)
		14%	One practical CNC / reverse engineering mini-project (team)
		24%	One two-part practical FDM mini-project (team)
		5%	Preparation for in-class activities (individual)
Mid-term	20%		Wednesday, October 11, 2:30 - 3:45 PM, 206 Randolph Hall
Final Exam	25%		Monday, December 11, 10:05 AM - 12:05 PM, 206 Randolph Hall
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Total	100%		

ME 5644 only: The additional research assignment for this course will count for 20 points, which are added to the 100 points shown above, for a total of 120 points maximum.

The work submitted by the student in this course may only be submitted in other courses (including thesis research) with *prior* written consent by *all* instructors involved. Further more, in such cases, the scope and the expectations of the homework will be expanded accordingly.

The mid-term and final exams will be closed book, closed notes. Crib-sheets, koofers (old exams), etc., will not be permitted. The final exam will be comprehensive, though with an emphasis on the material presented during the second half of the semester.

PASS/FAIL or AUDIT enrollment will not be permitted.

Students with disabilities or special needs will be accommodated.

The Honor Code

THE HONOR CODE WILL BE STRICTLY ENFORCED IN THIS COURSE. ALL ASSIGNMENTS SUBMITTED SHALL BE CONSIDERED GRADED WORK, UNLESS OTHERWISE NOTED. ALL ASPECTS OF YOUR COURSE WORK ARE COVERED BY THE HONOR SYSTEM. ANY SUSPECTED VIOLATIONS OF THE HONOR CODE WILL BE PROMPTLY REPORTED TO THE HONOR SYSTEM. HONESTY IN YOUR ACADEMIC WORK WILL DEVELOP INTO PROFESSIONAL INTEGRITY. THE FACULTY AND STUDENTS OF VIRGINIA TECH WILL NOT TOLERATE ANY FORM OF ACADEMIC DISHONESTY.

It is expected that the work you submit is yours alone. However, with the exception of the mid-term and final examinations, you are strongly encouraged to discuss freely with others the *concepts* involved, and to seek the assistance of the Virginia Tech Writing Center. For instance, you may help or receive help in debugging code, but you may not directly or indirectly take part in copying code.

All questions regarding the applicability of the Honor Code in this course should be directed to the course instructor for further clarification.