ChBE 4200 **Additive and Polymer-Based Manufacturing** **Spring 2024**

1 Catalog Description

Scaling up prototypes through industrial processes. Operating principles of advanced forms of 3D printing (stereolithography and powder bed fusion). How the properties of polymeric, ceramic, and metallic materials inform the 3D printing process and certification of printed parts. Computer aided modeling of manufactured parts with a focus on minimizing anisotropic properties and dimensional instability. Fundamentals of polymer melt flow. Simulation of flow, pressure, and temperature of polymer melt in mold cavities to optimize part fabrication. Students will have the opportunity to design a prototype injection mold and iterate on their design using flow simulation software and 3D printing. Prerequisite: DF 2100.

Please note: This semester injection molding has been de-emphasized with Prof. Guelcher's offering of CHBE 4870: Polymer Science and Engineering. Additional content on large format 3D printing (screw extrusion) has been added.

2 Class Meeting Times

3 Instructors

Dr. David Florian
Email: David.C.Florian@Vanderbilt.edu
Office:
Office Hours:

4 Textbook

Required textbook: Additive Manufacturing Technologies. 3rd Edition. By Gibson, David Rosen, Brent Stucker, and Mahyar Khorasani.

The textbook is only required up until the Midterm and can be rented for the first part of the semester for a lower cost from Amazon: https://www.amazon.com/Additive-Manufacturing-Technologies-Ian-Gibson/dp/3030561267

5 Grading Policy

The contribution of each assignment to the final grade is listed below:

- 10% HW & Professionalism
- 20% Practicals (Technical proficiency and written)
    - Laser cutter (5%)
    - VPP (5%)
    - SLS (5%)
    - Multi-material printing (5%)
- 20% Mid Term

- 50% Projects
    - Setting Up GitHub Portfolio (5%)
    - Top-down (10%)
    - Multi-material (10%)
    - Microfluidic (10%)
    - Final Project (15%)

The final grade will be a computed from the weighted averages of all assignments. A letter grade will be assigned based on the following scale: **A** = 100-93, **A-** = 92-90, **B+** = 89 - 87, **B** = 86 - 83, **B-** = 82-80, **C+** = 79-77, **C** = 76-73, **C-** = 72-70, **D+** = 69 - 67, **D** = 66-63, **D-** = 63-60, **F** = below 60

6 Honor System

All students are expected to abide by Vanderbilt University's Honor Code. These expectations include the application of academic integrity and honesty in your class participation and assignments. *Students are not permitted to reference past work from students, including reports, 3D models, and examination material.*

AI-generated text is strictly prohibited for all assignments. The objective of this course is to cultivate and evaluate individual learning, critical thinking, and creative problem-solving skills. Therefore, students are required to reflect on their personal designs and iterative processes. Writeups that lack the specificity and detail that one would typically expect from a student writing about their own design will be subject to scrutiny.

7 Attendance and Late Work

This class features both in-person lectures and asynchronous material. Participation is required for in class activities and labs. If a student plans to be absent from graded in-class assignments, then the professor must be notified at least 48 hours in advanced. Rescheduling a makeup or excusing the student from the assignment is at the discretion of the professor. Doctor appointments and athletics are excusable absences but require proper documentation.

Students are afforded **one** 3-day grace period to submit a project late **OR** reschedule a proficiency training. Late work (outside of the 3-day grace period) or failure to attend a required training or in class assignment will result in a 0. Disputes regarding graded assignments must be brought to Professor Florian within a week of receiving the grade.

8 Professionalism

ChBE 4200 is the capstone course for the Digital Fabrication Minor. Students will operate both subtractive (laser cutting) and additive (FFF, SLA, SLS) manufacturing equipment in the classroom. These digital fabrication tools are both costly to repair and can present safety hazards when used improperly. Students will receive a professionalism grade based on the following criteria:

- Attendance and Participation
    - Students who are engaged in class are less likely to miss pertinent operating and safety instructions.
- Equipment Interaction

    - Students should follow all oral and written instructions when operating the equipment. For SLA and SLS printers, the post-processing of prints should be completed in a timely fashion to free up the printer for the next user. The post processing space should be left cleaner than it was found.
- Requesting help
    - Students should always request help when they encounter issues or are attempting to use the machine in a manner different than described in class (e.g., laser cutting a material not explicitly allowed). This is a period of training and mistakes will happen. Any issues should be promptly reported to Professor Florian in person or over email.

9 Instrument Proficiency Testing

Students will be asked to demonstrate proficiency of each instrument in one-on-one sessions with Professor Florian. Students are responsible for scheduling these sessions outside of class and arriving on time. Each proficiency test will include setting up, operating, and shutting down the instrument, as well as answering questions about how the machine operates

10 Accommodations

Vanderbilt is committed to equal opportunity for students with disabilities, as am I, your instructor. If you need course accommodations due to a disability, please contact VU Student Access Services to initiate the process. Rapid Prototyping (DF-2100) is a non-traditional course. Please preview the assignments below and/or schedule a meeting with Prof. Florian to discuss how VU-approved accommodations would apply to this course. Accommodations must be discussed prior to the due date of an assignment.

11 Digital Fabrication Lab Access

The Digital Fabrication Lab (DFL) is open Monday - Friday from 9 am to 5 pm. Students are expected to act professionally and safely in the DFL. Food and drinks are not allowed. Attempting to operate equipment that students are not trained on by Professor Florian is not permitted. All hand tools, components, parts, etc. cannot be borrowed or removed from the DFL. Failure to abide by these rules will result in the revoking of access to the space, which will prevent passing of this course.

12 Course Schedule

Practical Dates:

- Laser Cutting Practical: 1/24, Wednesday 8a-6p
- VPP Practical: In class 2/6
- SLS Practical: In class 2/15
- FFF Practical: In class 2/27

NO.	DATE	TOPIC	Chapter(s)	ASSIGNMENT DUE
1	1/9	Introduction + GitHub Website		
2	1/11	Fundamentals of Laser Cutting	2.7.1	
3	1/16	Laser Cutting Training		
4	1/18	UV Curable Polymer Systems	4.1-4.3	GitHub Portfolio Setup
5	1/23	Vat Photopolymerization (VPP)	4.4, 4.5.2	
		Laser Cutting Practical (1/24)		
6	1/25	VPP Training & Microfluidics Project Intro		HW1
7	1/30	Material Jetting		
8	2/1	uFluidic CAD modeling	7	VPP Practical (In Class)
9	2/6	Bioprinting	6.7	uFluidic CAD Check
10	2/8	Powder Bed Fusion (Polymers)	5, 14.4.1	HW2
11	2/13	Powder Bed Fusion (Metals)	3.4	uFluidic Molds Due
12	2/15	Thermoplastic Polymers		SLS Practical (In Class)
13	2/20	Advanced Topics in FFF & MM Project	6.1-6.6	HW3
14	2/22	Fundamentals of Screw Extrusion		Advanced Slicing Video
15	2/27	Large Format 3D Printing		FFF Practical (In Class)
16	2/29	Exam Review & MM Project Workday		HW4
17	3/5	Midterm		
18	3/7	uFluidic Testing		Multi-Material CAD Check
	3/12	*Spring Break*		
	3/14	*Spring Break*		
19	3/19	Top-Down CAD 1 & TD Project Intro		uFluidics GitHub Entry
20	3/21	Top-Down CAD 2 & Multi-Material Testing		
21	3/26	Top-Down CAD Workday		Multimaterial GitHub Entry
22	3/28	Final Project Intro		Top-Down CAD Check
23	4/2	Generative Design		
24	4/4	Generative Design		HW5 & Top-Down CAD Github
25	4/9	Generative Design		HW6
26	4/11	Final Project Workday		
27	4/16	Final Project Workday		
28	4/18	Final Project Testing		

Final Project GitHub Writeup Due: 4/24 @ 2:00 pm

13 **Homework Assignments**

- HW 1: Exploring Resins and Print Failures
- HW 2: Bioprinting Applications
- HW 3: DIY SLS Print Cleaning Apparatus
- HW 4: Large Format 3D Printing
- HW 5 & 6: Generative Design Practice