Spring 2019

CHE 415-102: Introduction to 3D Printing

Murat Guvendiren

CHE 415 - Introduction to 3D Printing
SPRING 2019
Otto H. York Department of Chemical and Materials Engineering - NJIT

Lectures and Labs: Thursday, 6:00 PM – 9:15 PM, TIER 109

Instructor
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Office Hours: Tuesday and Thursdays 2-3 PM (Appointment Only) – **TIER 109**

Course Description
This course introduces 3D printing technologies including history and basics of 3D printing, currently available 3D printing methods and printable materials as well as current and emerging applications of 3D printing. Students will get a general idea on the major players in 3D printing industry and global effects of 3D printing. The course will be composed of a lecture and a hands-on laboratory session, during which students will create a 3D design and print a functional prototype.

Target Enrollment: 30 students max (No exceptions)

Prerequisites: Junior standing or higher (contact Dr. Guvendiren for exceptions)

Course Objectives

1. Familiarize students with 3D printing technology
2. Develop the ability to assess printing methods and materials for specific applications
3. Develop ability to design and 3D print complex devices/tools
4. Explore future applications and opportunities of 3D printing
5. Explore manufacturing considerations for 3D printed devices including quality control and FDA (for medical devices) issues
6. Evaluate 3D printing industry and the global effects of 3D printing
7. Develop presentation skills and foster team work
8. Develop ability to search literature for peer-reviewed articles, and learn critical reading

Course Outline

- What is 3D printing?
- History and evolution of 3D printing technology
- Basics of 3D printing process (generalized process chain)
- Design for 3D printing
- Overview of 3D printing technologies and printable materials
- Vat Photopolymerization based printing
- Powder-based printing
- Extrusion-based printing
- Droplet-based printing
- Impact of low cost and open source systems
- Guidelines for process selection and execution

- Overview of current advancements in 3D printing
- Applications of 3D printing
- Overview of emerging areas (4-D printing, space, etc.)
- Literature survey
- Business opportunities and future directions

Learning Materials/Tools

Reference Text Book (recommended)**:** Additive Manufacturing Technologies – 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, by Ian Gibson, David Rosen, and Brent Stucker, Second Edition, Springer, New York.

Required CAD Software: Autodesk Fusion 360 (cloud-based CAD Design software). Fusion 360 is free for students. You are required to download this software in your OWN laptop. If you don't have a laptop, please contact Dr. Guvendiren.

System requirements: https://goo.gl/gUWyqi
Download page: https://www.autodesk.com/products/fusion-360/students-teachers-educators

Required Slicing Software: Flashprint software will be used for silicing the digital images for 3D printing. Our lab is equipped with Flashforge Inventor Dual Extrusion 3D Printer.

Link: https://flashforge-usa.com/pages/download

When to Download: These software are not required in the first week of the class. So please wait to download them. More detailed information will be provided in the first day of class.

Other Learning Material: PowerPoint presentations for each lecture will be posted on the Moodle webpage **AFTER** each lecture. Students are strongly encouraged to take notes during the lectures and integrate their notes into the provided documentation after each lecture.

Calculator: A scientific calculator is required.

Laboratory Materials/Supplies: All the materials and supplies needed for the laboratory section of the course will be provided by the Department. Students may be expected to SHARE some of the items.

Student Learning Outcomes

- Identify key 3D printing technologies, and corresponding major industry segments
- Identify key material properties for 3D printability for each printing technique
- Compare and differentiate printing methods and printable materials based on specific application
- Design a component or a functional device to meet desired needs with realistic design constrains considering the processing and the application
- Manufacture devices and tools using 3D printing
- Assess current and future applications of 3D printing
- Assess the 3D printing industry and the global effects of 3D printing particularly on engineering and manufacturing
- Ability to communicate effectively through written reports and oral presentations
- Ability to work as a team
- Effectively present technical and engineering problems to a "lay audience"

This course explicitly addresses the following student outcomes: 1-7

Detailed Course Schedule

Note: Course schedule is tentative and may change throughout the term. The instructor will communicate any changes. Class time is provided for topics of particular interest to students, or to provide additional instruction if class is running behind. Students wishing to suggest a special topic should speak with the instructor.

Month	Topics
Jan 24	Lecture: Introduction to 3D Printing Lab: Hands on training on 3D printers
Jan 31	Lecture: Software and data formats for AM Lab: Hands on training on CAD and slicing software
Feb 7	Lecture: 3D Printing Industry and Its Impact (Group Presentations) Lab: Hands on training on CAD / Design Project I
Feb 14	Lecture: Extrusion based printing technologies Lab: Design Project I (Printing/Troubleshooting)
Feb 21	Lecture: Paper Presentations (4) Lab: Design Project II
Feb 28	Lecture: Vat Photopolymerization printing technologies Lab: Design Project II (Printing/Troubleshooting)
Mar 7	Lecture: Paper Presentations (4) Lab: Design Project III
Mar 14	Lecture: Droplet-based printing technologies (Paper presentations, 2) Lab: Design Project III (Printing/Troubleshooting)
Mar 21	No Class - Spring Break (March 17-24)
Mar 28	Lecture: Paper Presentations (3) Lab: Design Project III (Printing/Troubleshooting)
April 4	Lecture: Powder based printing technologies (Paper presentations, 2) Lab: Design Project IV
April 11	Lecture: Bioprinting and Applications Lab: Design Project IV (Printing/Troubleshooting)
April 18	Lecture: Current and Emerging Applications of AM Lab: Final Project Workshop
April 25	Lecture: Online open resources for 3D printing Lab: Final Project Workshop
May 2	Lecture: Final Project Presentations Lab: Final Project Report and Print Due

Assignments and Grading

Group Presentations: Each team will deliver in class presentations, which will require internet search. If you miss a presentation, you will receive a zero (no exceptions).

Paper Presentations: Each student (or groups of two/three) will be required to present one paper to class. Student presentations will start in Week 3. This presentation will be followed by class discussions related to the presentation. All students will be expected to read the paper beforehand and be prepared to discuss the paper. If you miss a presentation, you will receive a zero (no exceptions).

Design Challenge: Students will be grouped into teams (rotating for every challenge) and will develop functional digital designs and 3D print these designs (and show their function). Usually you will have a week to return your design (determined by the Instructor and announced before the assignment of the project). Late designs (up to a week) will be excepted but you will receive half the credit.

Final Group Project: Each team will be given a Final Design Project, and will be required to come up with a simple but creative design (a tool or a device, TBD). Each team will be required to prepare a written report and present their design process by the end of the course. No late returns are excepted.

Grading Criteria:

- Quiz/HW 15%
- Group Presentation 12%
- Paper Presentation 10%
- Design Challenge 30%
- Final Group Project 30%
  - Printed Device 10%
  - Written Report 10%
  - Presentation 10%
- *Extra Credits 3%

***** The final grade for this course will be calculated out of 100 points. However, there will be opportunities to get extra 3 points (total) during the semester, which will be directly added to your total grade.

Your performance will be evaluated on an absolute scale and not relative to the performance of other students in class. Final letter grades will be awarded based on your weighted average score (see weighting above) and a table of average score–letter grade categories (see below).

Grading will be based on:

A:	90 – 100%
B+:	85 – 89%
B:	80 – 84%
C+:	70 – 79%
C:	60 – 69%
D:	50 – 59%
F:	0 – 49%

Rules and Expectations during the Lectures/Labs

- Please come to the class before the lecture starts or at least ON TIME. Under no circumstances, you should distract your peers and the instructor.
- **Note that attendance is mandatory as the course requires direct involvement of each student. Each student is allowed one unexcused absence, and in the event, that he/she is absent three or more times (exceptions may occur), he/she will automatically fail the class.** Students are expected to come to class having read the assigned material, completed the

assignment, and well prepared to engage in dialogue regarding the assigned material. All reading and other preparatory assignments must be completed by their due date(s).

- The **total number** of Quizzes and the **format and scheduling of each QUIZ** will be determined by the Instructor, and **could vary**. Quiz will be announced a week before.
- There will be **NO MAKE-UP,** if you miss a Quiz or a Presentation. You will receive a **ZERO**.
- **Late Design Projects (ONLY up to a week) will be accepted but you will receive half the total credit.**
- **NO LATE REPORT/PRESENTATION will be accepted and NO MAKE-UP** will be offered for the Final Design Project.
- You are responsible for all information given in lectures (oral, written or handouts, posted notes), whether you are present or not during the lectures.
- **ABSOLUTELY No cell phone/laptop use, no video/audio recording, and NO FOOD allowed any time during the lecture.** Laptops will only be used when instructed so for the lectures (to be announced).
- **You can ONLY use the laboratory in the presence of a TA or the Instructor.** Printers will ONLY be available during lab hours – additional times could be arranged by the Instructor.

Disability Support Services

NJIT provides disability support services in the campus. If you need accommodations due to a disability please contact Chantonette Lyles, Associate Director of Disability Support Services, Fenster Hall Room 260 to discuss your specific needs. A Letter of Accommodation Eligibility from the Disability Support Services office authorizing your accommodations will be required.