Course Syllabi:

CHE 722-102 – Additive Manufacturing and Applications

Course Description

This course summarizes additive manufacturing technologies and current (and emerging) applications. Technologies including extrusion-based printing, droplet-based printing, powder-based printing, and vat photopolymerization printing will be discussed in detail with respect to printing parameters, printable materials, and end-product properties. Students will learn how to select the proper printing technology and materials for particular applications. This course will be composed of a lecture and a hands-on laboratory session, during which students will create 3D designs and print functional prototypes. Students will be challenged every week to develop innovative and functioning 3D printed components.

Instructor

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Teaching Assistant(s)

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Prerequisites

CHE 624 Transport Phenomena
CHE 626 Mathematical Methods in Chemical Engineering
Other equivalent courses can be acceptable for other engineering students with the permission of the instructor.

Reference Books

- Additive Manufacturing Technologies – 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, by Ian Gibson, David Rosen, and Brent Stucker, Second Edition, Springer, New York. **(You may want to purchase this book !!!)**
- 3D Printing and Additive Manufacturing – Principles and Applications, by Chee Kai Chua and Kah Fai Leong, The 4th Edition, World Scientific.

Course Objectives

1. Familiarize students with 3D printing technology
2. Develop the ability to assess printing methods and materials (inks) for specific applications
3. Develop ability to design and 3D print 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. Explore the 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)
- 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
- Design for 3D printing
- Overview of current advancements in 3D printing
- Applications of 3D printing
- Overview of emerging areas (4-D printing, space, etc.)
- Literature survey
- Overview of 3D printing industry
- Business opportunities and future directions

Target Enrollment

30 students

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 for specific
- Design a component or device to meet desired needs with realistic constrains for 3D printing
- 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 manufacturing
- Ability to communicate effectively through written reports and oral presentations.
- Effectively present technical and engineering problems to a “lay audience”
- Ability to work as a team.
- Ability to effectively use available data bases at NJIT for literature search
- Critical reading

Course Format

The course will consist of a lecture and a hands-on laboratory session with extensive participation between students and the instructor. The following is the tentative Course Schedule.

Note that the actual course content for each week will be subject to alterations to accommodate scheduling needs.

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.

Week	Session Objective	Description	Pre-Assigned Readings
1	*Welcome.* Introduce the course objectives and syllabus. Familiarize the students with the history and development of 3D printing technology. Interactive discussion on 3D printing. Team building for group assignments and presentations.	Lecture: • Course introduction • History of technological advancements • Class discussion • Team building • Literature review assignment and scheduling	
2	*Introduction to 3D printing.* Introduce the 3D printing process including computer aided design (CAD), the interface and basic tools available for 3D printing (software requirements, compatible file formats, etc.). Students to finalize their teams. LAB: Hands-on training on how to use the printers. 3D printing of demos.	Lecture: • Introduction to 3D printing Lab: • 3D printing demo designs. • Digital design and slicing prectices	• Students to finalize teams

Week	Session Objective	Description	Pre-Assigned Readings
3	*Software for Additive Manufacturing.* Preparation of Computer Aided Design (CAD) models, creating STL files from CAD images, image slicing, file manipulation, and problems with files. LAB: Design and printing exercises.	Lecture: • Introduction to 3D printing (design, slicing, and printing) Lab: • Design and printing exercises.	• *Class presentations:* Students were given journal articles to review and present to class (2 presentations per class from Week 4 to Week 13. 10 min each presentation followed by class discussion).
4	*3D printing technology.* Overview of 3D printing methods and selection of ink materials (materials selection) for each method. Summary of limitations and advantages of each technique for specific application. (Class presentations followed by discussion) LAB: Design Challenge 1. Students will be given a design challenge, during which they will come up with a design, and 3d print a functional component. Students are expected to write a short report about their design.	Lecture: • 3D printing methods. • Ink formulations. • Materials selection for ink formulations. • Class presentations. Lab: • Design Challenge 1.	• *Class presentations* •
5	*Vat Photopolymerization based printing.* Printing technology, basics, materials, applications and limitations. LAB: Final Design Project assignment, and evaluation of Design Challenge 1. In lab demonstration of stereo lithography printing process.	Lecture: • Vat Photopolymerization Lab: • Final Design Project • Stereolithography printing • Design Challenge 2	• *Class presentations.* • *Design Challenge 1 due.*

Week	Session Objective	Description	Pre-Assigned Readings
6	*Powder-based printing.* Printing technology, basics, materials, applications and limitations. LAB: Design Challenge 2. In lab demonstration of powder-based printing process.	Lecture: • Powder based printing Lab: • Design Challenge 3 • Powder based printing	• *Class presentations* • *Design Challenge 2 due.*
7	*Extrusion-based printing.* Printing technology, basics, materials, applications and limitations. LAB: Design Challenge 2. In lab demonstration of powder-based printing process.	Lecture: • Extrusion based printing Lab: • Design Challenge 4 • Powder based printing	• *Class presentations* • *Design Challenge 3 due.*
8	*Bioplotting (Organ printing).* Students will learn details of this technique. Conditions for cell survival including possible applications will be discussed. LAB: Visit to Guvendiren lab (two teams at a time) for demonstration of bioplotting while other groups are working on their Final Project Design. Evaluation of Design Challenge 2.	Lecture: • Organ printing Lab: • Lab visit	• *Class presentations* • *Design Challenge 4 due.*
9	*Droplet-based printing.* Printing technology, basics, materials, applications and limitations. LAB: Visit to TBD lab (two teams at a time) for demonstration of inkjet printing while other groups are working on their Final Project Design.	Lecture: • Inkjet printing Lab: • Lab visit	• *Class presentations*
10	*Impact of low cost and open source systems* *Guidelines for process selection and execution* LAB: Design Challenge 3.	Lecture: • Open source • Process selection Lab: • Design Challenge 5.	• *Class presentations* •

Week	Session Objective	Description	Pre-Assigned Readings
11	*Future of 3D printing.* Students will be familiarized with advanced terminologies such as 4D Printing and zero(micro)-gravity printing. Students will explore how time (as the 4th dimension) impacts the design and fabrication process. Students will be challenged to apply what they have learnt to space applications. Real life examples will be presented. Students will be required to write a page assay based on new possibilities in 3D fabrication. LAB: Evaluation of Design Challenge 3. Teams working on their final Design Project.	Lecture: • Future of 3D printing • Assay writing Lab: • Design Challenge 6.	• *Class presentations* • *Design Challenge 5 due.*
12	*3D printing industry.* Students will be familiarized with the major players in 3D printing industry, and global effects of 3D printing. LAB: Evaluation of Design Challenge 3. Teams working on their final Design Project.	Lecture: • 3D printing industry • Global effects • Class presentations Lab: • Final Design Project.	• *Class presentations* • *Student assays due* • *Design Challenge 6 due.*
13	*Team Presentations and Assessments.* Teams will give a short (10 min) lay presentation on their design: Why they chose the design? What were the main obstacles in their design? etc.	• Final Design Project Presentations	• *Team presentations*
14	*Team Presentations and Assessments.* Teams will give a short (10 min) presentation on their design: Why they chose the design? What were the main obstacles in their design? etc.	• Final Design Project Presentations	• *Team presentations* • *Team's Report due.*

Assignments

Each student will be required to present **at least** one paper to the 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. In addition to the paper presentations, students will be expected to form teams (Week 1) and will

develop simple designs, in each lab session, based upon the examples provided by the instructor for FDM type 3D printing (Design Challenge). In addition, 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.

Grading Criteria

- Quizzes 20%
- Paper Presentation (Literature Review) 15%
  - Presentation 12%
  - Participation (e.g., asking questions) 3%
- Design Challenges 30%
- Final Group Project 35%
  - Printed Device 10%
  - Written Report 10%
  - Group Presentation 15%
- *Extra Credits 5%

Note that attendance is mandatory. 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** (e.g., **announced and/or unannounced**).

***** There will be **NO MAKE-UP,** if you miss a Quiz, Design Challenge, Paper Presentation, and/or Final Project Presentation, you will receive **ZERO**.

*** The final grade for this course will be calculated out of 100 points. However, there will be opportunities to get extra 5 points (total) during the semester, which will be directly added to your total grade.**

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.