Syllabus of MECH6910S

Course Title

Advanced additive manufacturing and topology optimization

Instructors

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Course Description

This course introduces seven state-of-the-art additive manufacturing (AM) technologies that apply to various materials. The physical principle, theoretical modeling, and the effects of different process parameters are derived and analyzed. Based on the knowledge of the AM processes, computer-aided tools, and specific design principles for AM are also discussed.

Among the design guidelines, the concept and practices of topology optimization are highlighted. The students will learn to generate structurally optimal designs based on loads, constraints, and other required product performance and manufacturing conditions. The course also provides experimental sessions to manufacture the structural optimized parts with either metal selective laser sintering or continuous fiber-reinforced additive manufacturing.

Learning Objectives

By the end of this course, the students will be able to:

- Understand different kinds of AM processes and their underlining principles,
- Select specific materials and AM processes for a given application,
- Evaluate, analyze, and optimize for the AM performance,
- Cultivate a “design-for-AM” skillset that leads to successful 3D prints,
- Create, fabricate, measure, and test parts with 3D printers,
- Perform topology optimization for additive manufacturing processes.

Textbook

Gibson, I., Rosen, D. W., Stucker, B., & Khorasani, M. (2021). Additive manufacturing technologies. Springer.
https://link.springer.com/book/10.1007%2F978-3-030-56127-7
Sigmund, O., & Maute, K. (2004). Topology Optimization: Theory, Methods and Applications. Springer.
https://link.springer.com/book/10.1007/978-3-662-05086-6

Reference Books

- Gebhardt, A., & Hötter, J. S. (2016). Additive manufacturing: 3D printing for prototyping and manufacturing. Hanser Publishers.
  https://www.sciencedirect.com/book/9781569905821/additive-manufacturing
- Srivastava, M., Rathee, S., Maheshwari, S., & Kundra, T. K. (2019). Additive manufacturing: fundamentals and advancements. CRC Press.
  https://www.taylorfrancis.com/books/mono/10.1201/9781351049382/additive-manufacturing-manu-srivastava-sandeep-rathee-sachin-maheshwari-kundra

Grading Policy

Homework	Midterm Exam	Lab	Final Project
25%	25%	25%	25%

Extra points will be given to students **voted to be most helpful to others and future teaching of the course**.

Prerequisite

- MECH 2410 Engineering Materials (preferred)
- MECH 2520 (3520) Design and Manufacturing (preferred)
- MECH 3510 CAD/CAM (preferred)

Course Schedule

Week	Topic
1	• AM introduction • Development of AM technologies and different classifications • Representative industrial applications of AM • Comparison of AM technologies to subtractive manufacturing
2	• Extrusion-based AM systems • Fused deposition modeling • Material properties of thermoplastics polymers
3	• Vat photopolymerization AM systems • Material properties of UV curable materials • Stereolithography • Digital light processing
4	• Powder bed fusion AM systems • Material properties of the metal, polymer, ceramic powders • Laser sintering
5	• Direct energy deposition AM system • Processing–Structure–Properties Relationships • AM process planning • Five-axis fused deposition modeling AM
6	• Binder jetting and material jetting AM system • AM technologies for composite
7	• **Midterm exam** • Review of CAD, CAM fundamentals • Design for AM
8	• Topology optimization introduction • Optimization problem introduction and solvers
9	• Struss topology optimization problem • Constraints and objectives in topology optimization
10	• Prelab • Guidelines for process and material selection
11	• Design with anisotropic material • Lab (Manufacturing and testing of the designed part)
12	• Optimal design of multi-functional structures
13	• Advanced solvers in topology optimization