# ME 8930 Laser-based Manufacturing and Materials Processing

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**Textbook:**

- Laser Material Processing (4th Edition), W.M. Steen and J. Mazumder, Springer 2010, ISBN 978-1-84996-061-8. (Online version available in Marriot Library)

**Other Reading Materials:**

- The Theory of Laser Materials Processing: Heat and Mass Transfer in Modern Technology**,** J. Dowden, Springer (2009), ISBN-13 978-1-4020-9339-5.

**Course Description:**

Due to the significant advances of lasers, laser-based manufacturing and material processing have been widely used in many industry sectors, including energy, aerospace/aeronautics, automotive, medical, electronics, etc. Laser-matter interaction is a complicated multi-physics process, involving laser absorption, electron excitation, heat/mass transfer, fluid/solid mechanics, and phase/microstructure change, etc. A good understanding of these fundamental mechanisms in laser material processing is crucial for the improvement of accuracy, efficiency and product quality in these processes. This course will provide students with a fundamental understanding of the lasers, optics, and laser-matter interaction mechanisms in various laser-based manufacturing and materials processing techniques. The students will also be exposed to different analytical and numerical models that capture the physics in material processing techniques. Opportunities will be created for the students to explore the possibilities of using laser-based techniques in their own research areas.

**Objectives:**

After completing the course, the students are expected to

- understand the fundamentals of laser physics, laser optics, and laser-material interaction mechanisms;
- be familiar with various laser-based manufacturing and materials processing techniques, and understand the important physical mechanisms during this processes;
- understand the basic analytical and numerical methods to investigate the heat transfer, fluid/solid mechanics, and phase/microstructure changes in various laser-based manufacturing and materials processing techniques.

**Pre-requisite:**

- ME 3040 - Heat Transfer (or equivalent courses)
- ME 3080 - Fluid Mechanics (or equivalent courses)

**Course Structure:**

The course will comprise of classes, homework, term project and exams.

- Classes: In classes, the basic principles and characteristics of selected processes will be discussed through instructor lectures, video demonstrations and in-class discussions.
- Homework: Homework will be assigned on a regular basis. Homework will include short-answer questions, calculations problems and numerical modeling problems.
- Term project: A term project will be assigned to individual students. The deliverables include a

written report and an oral presentation to the class. The term project will be in one of the following formats (to be determined).

a) A literature study of a novel laser-based materials processing technique
b) A proposal of utilizing an existing laser-based materials processing technique for the current research of the students.
c) A project to use numerical modeling technique to investigate a specific problem in a selected laser-based materials processing technique.

- Exams: There will be one mid-term during the regular class hour, and one final exam (comprehensive) at the end of the semester.

To accommodate the differences between graduate and undergraduate students, the two groups of students will be assigned different homework, term project and exams.

**Course Grading Policy:**

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|---|---|
| Homework | 25% |
| Mid-term | 15% |
| Final | 25% |
| Term project | 35% |
| Total | 100% |

Grades: A (90 and above), B (80-89), C (60-79), F (59 and below)

**Topical Outline:**

1. Introduction (1)
2. Fundamentals of lasers and optics (2)
3. Fundamentals of laser-matter interaction (3)
4. Thermal impact by lasers: sintering, melting, re-crystallization, etc (6)
5. Thermo-mechanical impact by lasers: shock peening, hardening, annealing, forming, etc (6)
6. Laser additive manufacturing (6)
7. Laser subtractive manufacturing (6)
8. Micro- and nano-scale laser manufacturing (6)
9. Numerical modelling methods for laser manufacturing (6)
10. Term project presentations and tests (3)

**Academic integrity:**

"As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a "high seminary of learning." Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form."

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programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. This policy is located at http://www.clemson.edu/campus-life/campus-services/access/title-ix/. Mr. Jerry Knighton is the Clemson University Title IX Coordinator. He also is the Director of Access and Equity. His office is located at 111 Holtzendorff Hall, 864.656.3181 (voice) or 864.565.0899 (TDD).

**Disability access statement**
Students with disabilities requesting accommodations should make an appointment with Dr. Arlene Stewart (656-6848), Director of Disability Services, to discuss specific needs within the first month of classes. Students should present a Faculty Accommodation Letter from Student Disability Services when they meet with instructors. Accommodations are not retroactive and new Faculty Accommodation Letters must be presented each semester.