Fall 2015

# ENME 5097

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*University of New Orleans*

**Special Topics in Mechanical Engineering – Friction Stir Welding**
**ENME 5097-791**
**Fall 2015**

## INSTRUCTOR

Mechanical Engineering 5097 is taught by Dr. Michael Eller

Additional information:

Class Location: Classroom 2, South Mezzanine Training Center, Building 103, NASA Michoud Assembly Facility, New Orleans
Class Schedule: Fridays 1:30 – 4:30 PM (see detailed course schedule on last page)
Office Hours: Friday 12:00 – 1:00 PM
Cell Phone:
E-mail: meller@uno.edu

## COURSE OBJECTIVES

**Course Description**: This course is intended to develop a deeper understanding of the principles of mechanical engineering and materials science through investigation of the technology known as friction stir welding (FSW). Since FSW can be classified as a joining process, forming process, forging process, extrusion process, and heat treatment process (among other things), it is an ideal technology for understanding essential engineering processes and systems. The course is designed to include a lecture session and a laboratory session to enhance student's familiarity with the process. Laboratory session will include hands-on training with FSW equipment and actual welding of metallic parts and corresponding joint configurations that are of interest to the aerospace community. Students will be assigned to project teams and will complete a unique FSW investigation pertaining to a particular alloy combination, part configuration/orientation, and/or set of process parameters. The welded parts will be assessed in one or more forms (i.e. mechanical testing, microstructural evaluation, etc.). Teams will be responsible for completing a written paper and oral presentation discussing their results.

The 5097 Graduate variant of this course will include additional learning objectives as well as course requirements than the 4097 Undergraduate variant. Graduate students may be asked to come 30 minutes earlier than normal class time for an additional "graduate only" discussion that will include discussion of more advanced topics not covered in the normal lecture series. Graduate students should expect that quizzes/examinations can include more questions and more difficult questions with less emphasis on learned information from previous courses. During the project portion of the course, the graduate students will be teamed together in a single group or groups. The project scope will include additional elements of numerical analysis of previous weld data, prediction of material behavior, and evaluating empirical results against hypotheses. Lastly, the scope of the graduate projects will include additional welding configurations and/or investigations than the undergraduate teams. Extra presentation time will be allocated to the graduate teams to report on the additional scope and make conclusions on the data set as a whole.

**Primary Learning Objectives**:

1. Reinforce principles of mechanical engineering and materials science by teaching the fundamentals of friction stir welding (FSW)
2. Enhance understanding of engineering materials selection by learning about industry applications of FSW
3. Facilitate team-based FSW projects at the NASA Michoud Assembly Facility using National Center for Advanced Manufacturing (NCAM) machines and tools
4. Emphasize design for manufacturability when planning FSW projects and associated pre-FSW and post-FSW machining activities
5. Teach methods for analyzing results of FSW projects through metallurgical and mechanical testing
6. Use numerical methods to analyze previous FSW data and predict the outcome of follow-on welding trials
7. Assess the value of statistical methods for predicting and understanding the relationship of welding parameters on mechanical properties

## COURSE REQUIREMENTS

**Prerequisite**:

ENME 5097-791 is open to Mechanical Engineering graduate engineering students; co-listed as 4096-791 for undergraduate engineering students. All students must be a U.S. Citizen with proof of citizenship; requirement for non-escort security clearance at NASA-Michoud.

**Exams and Grading**:

Attainment of objectives is assessed by quizzes, mid-term exam, project written report, and project oral presentation.

(**Quizzes**: 5%) A total of 2 quizzes will be given during the course of the semester. The quizzes are strategically scheduled after the first 2 "Friday offs" to ensure that students are reviewing the assigned reading material. The quizzes are each comprised of no less than 5 questions and the combination of both quizzes will count for 5% of your total grade. Questions for graduate students will focus on the application of new knowledge versus applying older knowledge learned in previous courses.

(**Exams**: 50%) A midterm exam will be given that covers all the lecture material on the topic of FSW. Questions will measure students' understanding of friction stir welding through principles of mechanical engineering and materials science. Exam will be taken in class on the date specified in the syllabus. Graduate students can expect more questions on the exam than undergraduate students. Additionally, questions for graduate students will focus on the application of new knowledge versus applying older knowledge learned in previous courses.

(**Project Written Report**: 25%) The third deliverable for the course is a written report based on the group project. Student teams will be responsible for FSW a specific configuration of material and interpreting the results. Reports will include both quantitative and qualitative data analysis. Preliminary work (proposing a topic and getting feedback on preliminary analysis) may be included in homework assignments. Students will work on the project in small groups of

three to four students depending on the size of the class.Project written reports will be graded on attainment of projectgoals, completeness of results, proper interpretation of data, and use of engineering / materials science principles. Graduate students will also need to include numerical methods and statistics used to predict and analyze the outcome of welding trials.

(**Project Oral Presentation**: 20%) The fourth deliverable for the course is an oral presentation based on the group project. Student teams will be responsible for organizing their processes and results into presentation format to be presented in front of a professional audience (i.e. engineering professionals from Lockheed Martin, Boeing, Jacobs Engineering, Vivace, Dynetics, and/or NASA). Presentation format and oral delivery of presentations will be graded on the team's professionalism and ability to convey their project results accurately. Graduate students will receive approximately 50% more time than undergraduate teams to present the additional investigations/configurations completed by the team as well as the numerical methods used to enhance the prediction and understanding of results.

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| Midterm Exam | 50% |
| Project Written Report | 25% |
| Project Oral Presentation | 20 % |
| Quizzes | 5% |
| **TOTAL** | **100%** |

A = 90%-100%; B = 80%-89%; C = 70%-79%; D = 60%-69%; F = 0-59%

**Incomplete**: It is my policy to grant the incomplete grade only in cases of illness, accident, or change in work hours during the last weeks of classes. The attending physician or employer must verify the extreme emergency in writing.

**Attendance Policy**: Attendance will not be recorded for this course, but students missing class when quizzes and exams are given will not have the opportunity for make-up the exam or quiz unless the circumstances below are met. Availability for oral presentation will be collected early on in the course to avoid any student conflicts. All students must attend and present at the oral presentation or forfeit their oral presentation grade.

**Make-up Exams/Quizzes**: Make-up exams and quizzes will only be given for extraordinary circumstances. These circumstances are defined as events for which the student does not know about prior to the exam date, and over which the student has no control. **Examples are death in the family; acts of God, such as hurricanes, flooding, or other related weather events; hospitalization of the student or immediate family member, or dire illness of the student.** If any of these events should occur, it is the students' responsibility to inform the instructor as soon as it happens; a determination will be made at that point as to the possibility of providing a make-up.

**Student Conduct**: It is important that students conduct themselves responsibility while attending class inside the Michoud Assembly Facility campus including abiding by the government rules for non-escort badge holders (to be explained in further detail by the instructor). Students must wear long pants and closed toe / closed heel shoes for all classes since we will spend time in the laboratory for every meeting with exception of the final oral presentations.

## COURSE TEXTBOOKS (OPTIONAL)

1. Mishra, Rajiv S.; De, Partha Sarathi; Mahoney, Murray W., *Friction Stir Welding and Processing: Science and Engineering*, Springer, 2014. ISBN: 3319070436

2. Mishra, Rajiv S.; Mahoney, Murray W., *Friction Stir Welding and Processing*, ASM International, 2007. ISBN: 1615030972

## ACADEMIC INTEGRITY

Academic integrity is fundamental to the process of learning and evaluating academic performance. Academic dishonesty will not be tolerated. Academic dishonesty includes, but is not limited to, the following: cheating, plagiarism, tampering with academic records and examinations, falsifying identity, and being an accessory to acts of academic dishonesty. Refer to the Student Code of Conduct for further information. The Code is available online at http://www.studentaffairs.uno.edu.

## STUDENTS WITH DISABILITIES

It is University policy to provide, on a flexible and individualized basis, reasonable accommodations to students who have disabilities that may affect their ability to participate in course activities or to meet course requirements. Students with disabilities should contact the Office of Disability Services as well as their instructors to discuss their individual needs for accommodations. For more information, please go to http://www.ods.uno.edu.

## COMMUNICATIONS POLICY

### E-mail

Instructors will use UNO, LSU, and other college email addresses for communicating with the class. Please watch for occasional e-mails about the course since it is being held at a NASA facility (i.e. non-University owned location) and the instructor may have to send out updated accessibility instructions because of the sensitive nature of this facility. Lectures will be distributed to students ahead of the lecture date. Students should study new material prior to the lectures.

### Class Schedule

The course will be held every 2 Fridays during the Fall term with every 3$^{rd}$ Friday off (see detailed course schedule on the next page). Each class will run the full 3 hours with 11 sessions scheduled for the term. The 12$^{th}$ session will be reserved for the oral presentations where students must be available to present aspects of their project. Students with exam conflicts may leave early and/or arrive late if necessary. **If for some reason the schedule must be altered, the instructor will send an email to the class indicating the change.**

## COURSE SCHEDULE

| Week | Classroom Lecture (~1 hour) | FSW Laboratory (~2 hours) |
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| August 21 | Introduction to FSW / NCAM / NASA-Michoud | Demonstration on FSW machines / Plant Tour / Safety |
| August 28 | Application of FSW | FSW Machine Introductory Training |
| September 4 | Labor Day Weekend (no class) | (Students to Review Introductory Material) |
| September 11 | Metallurgical Properties of FSW<br>Quiz #1 | Metallography & Machine Shop Equipment Training |
| September 18 | Mechanical Properties of FSW | FSW Machine Programming & Setup Instruction |
| September 25 | 3rd Session Off (no class) | (Students to Review Machine Programming & Setup) |
| October 2 | Design for FSW<br>Quiz #2 | FSW Trials & Macrograph Preparation |
| October 9 | Mid-Term Examination | Project Assignment, Team Formation, Develop Weld Plan |
| October 16 | UNO Mid-Semester Break (no class) | (Teams Complete Program Comments, Tooling Storyboard) |
| October 23 | Weld Testing Methodology | Set up Tooling, Prep Panels, Perform Initial FSWs |
| October 30 | Analysis of FSW Data | Perform Remaining FSWs, Rough-Cut Tensile and Macro Specimens |
| November 6 | 3rd Session Off (no class) | (Teams Configure Weld Data, Compile Visual Observations) |
| November 13 | Interpretation of FSW Test Results | Machine Tensiles, Mark, and Send to Test |
| November 20 | Exam Review, Technical Report Overview, Data Analysis | Evaluation of Macro Photos, Tensile Results |
| November 27 | Thanksgiving Break (no class) | |
| December 4 | Final Written Reports Due | Presentation Overview and Presentation Methods |
| December 11 | Final Exam Week - Final Presentations Due | Team Presentations to LM / Boeing / NASA Audience |