Course Number and Name:
Graduate: MENG-593 Special Lecture - Finite Element Analysis
Undergraduate: MENG-493 Special Lecture - Finite Element Analysis

Syllabus Revision: 1/27/2015 for 3-Week Summer Session (Madrid) 2015 (revised by A. Malik).
Subjects and topics delivered with relevance to aerospace, mechanical, civil, biomedical, and electrical engineering.

Instructor Information: Dr. Arif Malik, AE/ME Dept., St. Louis Campus, Office: 2019 MDH, Tel. (314) 977-8185, amalik8@slu.edu
Course Location: Madrid campus, room to be determined
Course Time: MTWR, 10am – 1:30pm (3-Week Madrid Campus Summer Session, May 18 –June 5, 2015)
Office Hours: MTWR, 9am-10am (location TBA)
Course Website: https://sites.google.com/a/slu.edu/meng-534-finite-element-analysis-i/

Current Catalog Description: Mathematical background (variational forms for 1D and 2D, Rayleigh Ritz, Galerkin, element matrices and assembly, formulation of axial/truss/beam/plane-frame structural elements, 2D field problem formulation, linear and triangular elements for heat transfer/irrotational flow, torsion of noncircular sections, elasticity, higher order and mapped elements, numerical integration). Lab applications and project included as part of lecture.

Prerequisites: ESCI 310, MATH 370 or equivalent


References or other course material:
Moaveni, S., Finite Element Analysis: Theory and Application with ANSYS, Prentice-Hall, 1999

Course Objectives:
• Gain understanding of mathematical background (variational methods, weighted residual methods)
• Understand and apply shape functions to obtain continuous state variable distributions
• Learn to assemble and solve finite element matrix system of equations
• Understand derivation of common structural elements (axial/truss/beam/plane-frame)
• Learn to formulate 2D field problem matrix system of equations
• Derive 2D triangular and bilinear rectangular elements for heat transfer, irrotational flow
• Learn to formulate finite element problems in 2D elasticity theory
• Understand formulation for higher-order and mapped elements
• Learn numerical integration techniques such as Gauss Quadrature
• Learn to write finite element code for structural members / elasticity applications in MATLAB
• Gain experience using commercial finite element packages (e.g. ABAQUS, CREO (ProMechanica)
Class/Laboratory Schedule:

**Lecture:** Four 210 minute class periods per week; 3 weeks (Monday to Thursday).

**Lab:** Incorporated in lecture. Madrid Campus access to MATLAB and ABAQUS needed.

**Tentative LECTURE Schedule:**

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<td>Variational Statement of the Problem</td>
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<td>5</td>
<td>Assembly, Cont., Direct Stiffness Method</td>
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<td>Properties of Global Stiffness Matrix</td>
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<td>Truss Element</td>
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<td>Beam Element</td>
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<td><strong>EXAM II</strong></td>
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<td>Formulations for Linear Triangular and Rectangular Elements</td>
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<td>Torsion of Non-Circular Sections (time permitting)</td>
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<td>Higher Order and Mapped Elements</td>
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<td>14</td>
<td>Numerically Integrated Elements</td>
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<td>15</td>
<td>Theory of Elasticity</td>
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<td><strong>Final Project Due Date TBD</strong></td>
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<td><strong>FINAL EXAM DATE TBD</strong></td>
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**Relation to 400-level courses.** The undergraduate counterpart course, MENG 493, shares a common lecture with the graduate course, MENG 593. Graduate students are expected to obtain a more in-depth understanding of the course materials, particularly with regard to derivations and advanced applications of the analytical principles and techniques. The expected performance of graduate students exceeds that of undergraduates, and is assessed by solving additional exam problems, conducting more challenging project work, investigating the relevant state-of-the-art through review of published works, performing independent study, and occasionally lecturing or teaching labs to the undergraduates. Commonality of the course between graduates and undergraduates varies between 60% and 80%.

**Academic Background Required:** The mathematical background required for this course is nothing more than undergraduate-level calculus, differential equations and matrix algebra. The completion of various homework assignments may also require a working knowledge of one or more standard or high-
level programming languages (e.g., MATLAB, Octave, C++, Mathematica, Maple). It is also assumed that the student has at least an introductory background in mechanics of solids or strengths of materials.

**Lab Purpose:** The purpose of the laboratory is to introduce the student to modern application of finite element analysis to problems in structural and solid mechanics, and to illustrate both its power and potential pitfalls. The laboratory will utilize the commercial software package ABAQUS, which is one of the leading industry standards in computational mechanics. Because of the lecture time required for initial development of the theory, it is not possible to exactly coordinate the laboratory and lecture materials. As such, the laboratory will be conducted somewhat independently from the lecture, although material from lecture will be emphasized where appropriate.

**Homework:** Homework will be assigned on a regular basis, usually weekly. No late homework will be accepted without prior instructor approval. Students registered for MENG 593 (graduate-level) will periodically receive additional homework problems, which MUST be completed for a passing course grade. Such additional problems will be accepted late with a penalty of 20%. Graduate-level assignments completed by students registered for MENG 493 will be counted as extra credit, but must be submitted by the due date.

**Assessment Methods:**
1. Two in-class exams
2. Final in-class exam
3. Weekly homework (hand calculations and/or computer assignments)
4. Weekly labs and two Projects (teams of two students per project)

**Continuous Improvement Process:**
Outcomes from the assessment methods will indicate any deficiencies in the learning process. Corrective actions to address deficiencies will be in the form of discussions and workshops.

**Grading:**
- Homework: 10%
- Exams I, II: 20%
- Labs/Projects: 30%
- Final Exam: 20%

**Exam Policy:** The only materials permitted for the exams are a calculator and ONE SIDE of an 8.5”x11” HANDWRITTEN formula sheet, which must be turned in with the exam. A total of four (4) 8.5"x11" handwritten formula sheets will be permitted for the Final Exam.

**Important Notes:**
1. Failure to complete any of the exams or the final project will result in a grade of “I” (incomplete) for the course.
2. Late homework will not be graded without PRIOR instructor permission.
3. No make-up exams will be given unless permission by the instructor is given prior to the scheduled exam for a qualifying absence, as determined by the instructor or by university policy.
4. Cheating will result in an automatic grade of “F” for the course.
5. Cooperative learning is encouraged (i.e. sharing ideas on homework or projects) but you must understand the material, and turn in your own work. Copying homework from another student constitutes cheating. You will most likely not perform well in this course unless you do and understand the homework.
6. Homework must be legible. Do not use spiral notebook pages. Staple all pages. Show units for all quantities. Homework violating these criteria will not be graded.

**Disability Services**
Students who believe that, due to the impact of a disability, they may need academic accommodations in order to meet the requirements of this, or any other, class at Saint Louis University are encouraged to
contact the Office of Disabilities Services. Confidentiality will be observed in all inquiries.

**Academic Integrity (provided here is the general university policy)**
The University is a community of learning, whose effectiveness requires an environment of mutual trust and integrity, such as would be expected at a Jesuit, Catholic institution. As members of this community, students, faculty, and staff members share the responsibility to maintain this environment. Academic dishonesty violates it. Although not all forms of academic dishonesty can be listed here, it can be said in general that soliciting, receiving, or providing any unauthorized assistance in the completion of any work submitted toward academic credit is dishonest. It not only violates the mutual trust necessary between faculty and students but also undermines the validity of the University’s evaluation of students and takes unfair advantage of fellow students. Further, it is the responsibility of any student who observes such dishonest conduct to call it to the attention of a faculty member or administrator.

**Contribution to meeting the professional component:**

<table>
<thead>
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<th>Category</th>
<th>Content (by credit hour)</th>
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<tr>
<td>Engineering Science</td>
<td>1.0</td>
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<tr>
<td>Engineering Design</td>
<td>2.0</td>
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<tr>
<td>Other</td>
<td>none</td>
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**Relation to Program Outcomes:**

(a): This course contributes to our students’ ability to apply knowledge of mathematics, science, and engineering.
(b): This course contributes to our students’ ability to design and conduct experiments, as well as to analyze and interpret data.
(c): This course contributes to our students’ ability to design a system, component, or process to meet desired needs.
(d): This course contributes to our students’ ability to function on multi-disciplinary teams.
(e): This course contributes to our students’ ability to identify, formulate, and solve engineering problems.
(g): This course contributes to our students’ ability to communicate effectively.
(i): This course contributes to our students’ recognition of the need for, and an ability to engage in life-long learning.
(k): This course contributes to our students’ ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.