



South Dakota School of Mines & Technology
College of Engineering



ME-428 Applied Finite Element Analysis
Fall 2009

Instructor

Karim Heinz Muci, Ph.D.

Professor, Mechanical Engineering Department

Co-Director, Computational Mechanics Laboratory (CML)

Office: Civil & Mechanical Engineering Bldg., Computational Mechanics Laboratory, CM-171

Phone: (605)-394-2430 Fax: (605)-394-2405

E-mail: Karim.Muci@sdsmt.edu

Office Hours

Monday, Wednesday and Friday, 11:00 am – 12:00 noon

Tuesday and Thursday, 1:00 pm – 3:00 pm

Other times may be possible making and appointment at the end of one of the lecture hours.

Lecture Hours

Monday and Wednesday, 2:00 pm – 2:50 pm

Lab Hours

Monday and Wednesday, 3:00 pm – 4:00 pm

Classroom

Theory: Computational Mechanics Laboratory, CM-266

Lab: Computational Mechanics Laboratory, CM-268

Web Site

<http://speedy.sdsmt.edu/~kmuci/>

In the “Course Materials” section of this web site the instructor will be posting during the semester lecture notes and other important information. The students must check this web site on a regular basis.

Credits

3 (2-1)

Prerequisites

ME-316 Solid Mechanics or permission of instructor.

Textbook

- Karim H. Muci: *Introduction to the Finite Element Method*. Lecture Notes.
Note: Available in pdf format in the web site for the course.

Suggested References

- Jacob Fish and Ted Belytschko: *A First Course in Finite Elements*. John Wiley and Sons, 2007. ISBN 978-0-470-03580-1
- Daryl L. Logan: *A First Course in the Finite Element Method*. Fourth Edition. Thomson, 2007. ISBN 0-534-55298-6

Useful References

- David S. Burnett: *Finite Element Analysis, From Concepts to Applications*. Addison Wesley, 1987.
- M. J. Fagan: *Finite Element Analysis, Theory and Practice*. Addison Wesley Longman, 1992.
- Kenneth H. Huebner, Donald L. Dewhirst, Douglas E. Smith, and Ted G. Bryon: *The Finite Element Method for Engineers*. Fourth Edition. John Wiley & Sons, 2001.
- Klaus-Jürgen Bathe: *Finite Element Procedures*. Prentice-Hall, 1996.
- O. C. Zienkiewicz and R. L. Taylor: *The Finite Element Method. Volume I: Basic Formulation and Linear Problems*. Fourth Edition. McGraw-Hill, 1989.

Expectations for Incoming Students

- The students are expected to enter the class with a good working knowledge of:
 - ✓ Applied Solid Mechanics
 - ✓ Calculus
 - ✓ Ordinary Differential Equations
 - ✓ Basic Numerical Methods
- Basic computer skills, such as the ability to work in the MS Windows environment, are a prerequisite.
- The students should be able to comfortably work with MS Excel, MS Word, and MS Power Point.
- The students should be able to use the software Mathcad (or another program with similar capabilities) or they should be able to program in their favorite programming language.

Student Effort

During each week, the student is expected to spend between six and eight hours outside of the classroom in preparation for class, studying the textbook and lecture notes, and solving homework assignments and projects. The student is strongly encouraged to study the textbook and the lecture notes and to carefully work all assigned computer tutorials.

Course Description (According to the Undergraduate Catalog)

Basic mathematical concepts of finite element analysis will be covered. The students will learn finite element modeling using state of the art software, including solid modeling. Modeling techniques for beams, frames, two and three-dimensional solids, and thin walled structures will be covered in the course.

Course Goal

The main goal of the course is to provide to the students all the necessary information and training that will allow them to start using in an appropriate fashion the Finite Element Method

(FEM) to solve boundary value problems that are governed by one or more linear partial differential equations. To achieve this goal, three different aspects that are closely related are considered:

- The theoretical foundations of the Finite Element Method.
- The programming of the Finite Element Method in the digital computer.
- The use of existing software that employs the Finite Element Method.

Nowadays there is a great variety of commercial software that can be employed to solve many different types of engineering problems using the Finite Element Method. Thus, in most cases, an engineer won't have to carry out the mathematical formulation and the numerical implementation of the method. However, it is not possible to use those computer codes in a reliable and efficient manner if the user doesn't know the theoretical foundations of the method and if he/she doesn't have a clear idea of how those programs work.

Course Objectives

After taking this course the student should be able to:

- Prepare a finite element model for a simple static stress analysis or heat transfer problem.
- Use the finite element method to perform the static stress analysis of a component made of a linear elastic material.
- Use the finite element method to perform a simple linear, steady state, heat transfer analysis.
- Explain the sources of error associated with a finite element analysis and perform a convergence study.
- Interpret the results obtained from a simple static stress or heat transfer finite element analysis.

Expected Outcomes

After taking this course the student should be able to:

1. Explain the finite element notation and terminology.
2. Explain the mathematical foundations of the finite element method.
3. Apply the Direct Method, the Variational Method and the Weighted Residuals Method to formulate the element equations for linear, time-independent, 1-D problems.
4. Explain how the element equations are assembled to obtain the system equations for a given problem.
5. Apply the assembly process to generate the system equations for simple models.
6. Define the boundary conditions for a given problem and explain how they are applied to the assembled system of equations.
7. Be familiar with different types of elements and understand their advantages and limitations.
8. Carry out a convergence study for a given model and estimate the accuracy of the results.
9. Decide when thin shell, plane stress, plane strain, axisymmetric, or solid elements must be used to perform the analysis of a mechanical component.
10. Use a commercial finite element program to perform the static stress analysis of a component made of a linear elastic material.
11. Use a commercial finite element program to perform a simple linear, steady state, heat transfer analysis.
12. Prepare a technical report summarizing the modeling approach and the results corresponding to a simulation performed using the finite element method.

Topics

☑ *Theory*

1. Introduction to the Finite Element Method.
2. The Direct Method.
3. The Variational Method.
4. The Weighted Residuals Method.
5. Different types of one, two and three-dimensional elements.

☑ *Programming*

1. Description of the fundamental modules that constitute a Finite Element computer program.
2. Study of computer codes developed for educational purposes and/or development of simple computer codes.

☑ *Practice*

1. Description of typical pre and post-processing modules.
2. Description of typical analysis modules.
3. Use of educational and/or sophisticated Finite Element software on a PC.
4. Analysis of problems in the areas of Stress Analysis and Heat Transfer.
5. Practical aspects related to the creation of a Finite Element model for a given problem.

Computer Usage

- The students will use one commercial software package that employs the Finite Element Method. The instructor and/or the GTA will provide a brief introduction to the software and the students will be responsible to learn all the details on their own during out-of-class time.
- The lab sessions will be held in a Computer Lab to use ABAQUS. During those sessions, certain basic functionalities within ABAQUS will be demonstrated.
- Students will be required to use various computer tools, including but not limited to word processing, CAD, spreadsheets, modeling, and programming.
- Written reports must be prepared in a word processor.
- For some of the assignments, the students may benefit from using software that has capabilities similar to the ones found in Mathcad, Mathematica, Maple, or Matlab.
- All the students must have and regularly read an e-mail account. During the semester, the instructor may send important information to the students via e-mail.
- Some assignments and tests may require electronic submission of work.

Grading

Exam 1	20 %	
Exam 2	20 %	(comprehensive)
Exam 3 (Final Exam)	30 %	(comprehensive)
Homework and Projects	30 %	(each will have a different weight based on difficulty)

Grading Scale

Grade	A	B	C	D	F
Average (%)	90-100	80-89	70-79	60-69	< 60

Exam Schedule

<i>Exam</i>	<i>Date</i>		<i>Time</i>	<i>Place</i>
1	Theory	Wednesday, October 7, 2009	2:00 – 2:50 pm	CM-266
	Lab	Wednesday, October 14, 2009	3:00 – 4:00 pm	CM-268
2	Theory	Monday, November 9, 2009	2:00 – 2:50 pm	CM-266
	Lab	Monday, November 16, 2009	3:00 – 4:00 pm	CM-268
3	Theory	Tuesday, December 15, 2009	2:00 pm – 3:50 pm	CM-266
	Lab	Wednesday, December 16, 2009	2:00 pm – 3:50 pm	CM-268

Academic Integrity

Students are expected to perform to a high standard of honesty and integrity in this course. Failure to do so will result in a final grade of “F” in addition to all the applicable sanctions according to all the rules and regulations currently in force at SDSM&T.

Note: According to the undergraduate catalog, academic dishonesty shall be defined to include all forms of cheating, fraud, plagiarism, or knowingly furnishing false information.

Attendance Policy

- Class attendance is mandatory: Every student is expected to attend each lecture and lab session.
- You must notify the instructor via e-mail and ahead of time (when possible) if you will be absent from class.
- Missing three or more class sessions (lectures and labs combined) may result, at the instructor’s discretion, in a final grade of “F” for the course.
- In general, only the following will be considered by the instructor as excused absences:
 - ✓ Medical emergencies.
 - ✓ Mandatory participation of the student in a school-sponsored event as described in the undergraduate catalog. (Note: In this situation, the student must follow all the guidelines and procedures specified in the undergraduate catalog).

Note: The instructor will consider all other circumstances on a case-by-case basis.

- If for some reason a student misses one class session, it is the student’s responsibility to find out which material was covered and which assignments were given.

Class Cancellation Policy

If a class is missed due to weather or instructor’s absence, anything planned for that class (homework due, exam, etc.) will occur during the next class session.

General Policies

- Late homework and projects will not be accepted.
- Homework and projects (both electronic and written) are due at the beginning of the class on the assigned due date.
- Unless specified otherwise by the instructor, all the homework assigned during one week will be turned in on Wednesday of the following week at the beginning of the class session.
- Since the total number of assignments (homework and projects) that will be given during the semester is relatively small, it is extremely important that you submit all of them. Missed

assignments may have a severe negative impact on your final grade for the course.

- The instructor may choose only a portion of a homework or project to grade, with the grade for that portion counting for the entire homework or project grade. No advance notice will be given as to which portion of a homework assignment or project will be graded.
- Grading of all materials will be strongly influenced by legibility and quality of presentation. If the instructor and/or the GTA cannot read it easily then it is wrong and the grade will be zero!
- Homework, project, or test materials submitted electronically must be properly submitted. Failure to do so will result in a grade of zero for the subject item.
- Homework submissions: (1) must not be done on spiral-edged paper; (2) must have all problems clearly labeled, neatly presented, and presented in the order in which they were assigned; and (3) must be stapled in the upper left corner (if more than one page).
- Preferred paper for homework assignments is engineering paper.
- All exams will be closed book and closed notes.
- Calculators will typically be required for the exams.
- There will be no makeup exams unless a student missed an exam due to a medical emergency or mandatory participation in a school-sponsored event. If you miss an exam due to other reasons, your grade in that exam will be zero.
- In the solution of any homework/project/exam problem that has a numeric answer, you must include the appropriate units in all the steps of the solution process and in the final answer. Failure to do so will automatically result in no credit given for that problem.
- While consulting fellow students outside of the classroom to understand the material is encouraged, each homework, project, or exam must represent work done only by the student (or by the team members, if the activity was carried out in teams at the request of the instructor). If this rule has been violated, all parties involved will receive the sanctions described in the section “Academic Integrity” of this syllabus.
- The reading assignments I give during a class period should be completed before the following class period. In class I will not cover point-by-point the material corresponding to a reading assignment.
- You must study in full detail all the solved examples presented in the textbook for each topic that we are covering in class.
- In some cases, I will only highlight the solution process for an example problem that I present in class. You must try to solve those problems on your own before the next class session.
- Requests for re-grades on homework, projects, or exams must be submitted *in writing* within one week of the class in which I returned the item on which you question the grade. Your request must explain in a very complete and detailed fashion which one is the question that you have regarding the grade. In this event, the entire homework/project/exam will be re-graded with possible adjustment in either direction.
- Items not claimed the first time I return them to the class must be picked up in my office within one week of the class in which I attempted to return it. Items not picked up after one week will be disposed of.
- Final exams will not be returned to the students. However, you can see your final exam if you stop by my office between the time I have the final exams graded and the end of the semester. After the end of the semester, all the final exams will be disposed of.
- Near the end of the semester a record of grades to date may be distributed to the students. If that is the case, each student should verify all grades and calculations. Any discrepancies observed

by the student must be called to the instructor's attention by the next class and must be supported by graded materials. The instructor may correct any errors at that time.

- If a student is found working on homework or projects corresponding to this or any other course during one of the lectures or lab sessions, he/she will automatically receive a grade of zero in all the homework and projects assigned during the semester. No exceptions will be made!

Policies for Assignments Carried Out in Teams at the Request of the Instructor

- It is expected that all team members will be actively involved in the completion of the assignment.
- If a student does not fully participate in the completion of an assignment, his/her name must not appear on the cover page of that assignment and a written notification signed by the other team members must be given to the instructor. Under these circumstances, the student will receive a grade of zero in that particular assignment. If this rule is violated, all the team members may receive, at the instructor's discretion, a grade of "F" for the course.
- In each assignment, the team will determine the % of participation of each one of its members.
- The name of each team member must be written on the cover page of the assignment and his/her % of participation must be clearly stated.
- The grade that each student will receive will be the grade given by the instructor and/or GTA times the % of participation of the student.
- In the case of a homework, the procedure to carry out the assignment will be as follows: (1) Each team member will do his/her best effort to solve on his/her own all the assigned problems, (2) the team members will meet and discuss the solution for each one of the problems, and (3) the team will document in a very professional manner the solution for each one of the problems.
- It is the responsibility of each team member to carefully read the final document that will be turned in to the instructor and make sure that he/she completely agrees with all its contents.
- Grading will be influenced by the number of team members.

Freedom in Learning Statement

Under Board of Regents and University policy student academic performance may be evaluated solely on an academic basis, not on opinions or conduct in matters unrelated to academic standards. Students should be free to take reasoned exception to the data or views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled. Students who believe that an academic evaluation reflects prejudiced or capricious consideration of student opinions or conduct unrelated to academic standards should contact the dean of the college which offers the class to initiate a review of the evaluation.

Use of Electronic Devices

Please turn off your cell phone before class starts. No text messaging in class. No headphones. If you wish to use a laptop in this class it should be only for the purpose of note taking or if at the request of the instructor the laptop is being used for a specific learning activity related to the course. Failure to follow this policy will be considered a form of cheating and a breach of academic integrity. Note that according to "Policy Governing Academic Integrity" in the SDSM&T Undergraduate Catalog, the instructor of record for this course has discretion of how acts of academic dishonesty are penalized, subject to the appeal process, and that "Penalties may range from

requiring the student to repeat the work in question to failure in the course.” No other use of any other electronic/computer media is allowed during class time.

Students with Special Needs

Students with special needs or requiring special accommodations should contact the instructor, Dr. Karim Heinz Muci, at 394-2430, and/or the campus ADA coordinator, Jolie McCoy, at 394-1924, at the *earliest* opportunity.