

Advanced Finite Element Methods

EGM 6352 Section ****

Class Periods: MWF 7th period (1:55 – 2:45 PM)

Location: E118 CSE

Academic Term: Spring 2022

Instructor:

Nam-Ho Kim

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352-575-0665

Office Hours: MWF 9th period (4:05 - 4:55 PM)

Teaching Assistant/Peer Mentor/Supervised Teaching Student:

Please contact through the Canvas website

- N/A

Course Description

Advanced topics in finite element analysis, emphasized on nonlinear problems including nonlinear elasticity, hyperelasticity, elastoplasticity (small and large deformation), and contact problems.

Course Pre-Requisites / Co-Requisites

EML 4507, EML 5526 or equivalent

Course Objectives

The objective of this course is to learn advanced topics in finite element methods so that this tool can be used for analysis, design, and optimization of engineering systems. Due to the variety of topics, specific topic will be emphasized in each year. The course offered in spring 2018 will focus on nonlinear structural analysis. Various nonlinearities in structural problems will be studied in the mathematical and numerical aspects. Students will also be exposed in computer programming and use of commercial finite element programs. The main topics covered in the course, in general, are outlined below.

1. Preliminary concepts: Index notation and summation rule, Vector and tensor calculus, Mechanics of continuous bodies, Boundary-value problem, Principle of minimum potential energy, and Principle of virtual work, Finite element formulation
2. Introduction to nonlinear FEA procedures: Linear vs. nonlinear problems, Solution procedure, Newton-Raphson method, Incremental N-R method, Incremental secant method
3. FEA for nonlinear elastic problems: Nonlinear elastic problems, Mapping and deformation gradient, Nonlinear strains, Polar decomposition, Deformation of volume and surface, Stress measures, Total Lagrangian formulation, Linearization (Tangent stiffness), Updated Lagrangian formulation, FE implementation of nonlinear elasticity, Hyperelasticity, strain energy density, Nearly incompressibility, Mooney-Rivline material, Mixed formulation
4. FEA for elastoplasticity: Behavior of ductile material, 1D elastoplasticity, Work hardening (isotropic and kinematic), FEA procedure for 1D elastoplasticity, Multi-dimensional elastoplasticity, Failure criteria, Equivalent stress and effective strain, Hardening model, Rate-independent elastoplasticity, Numerical integration for elastoplasticity, Return-mapping algorithm, Consistent tangent operator, Elastoplasticity with finite rotation, Objective stress rate, Finite deformation elastoplasticity with hyperelasticity, Multiplicative decomposition, Principle of maximum dissipation, Spectral decomposition and time integration, Return mapping in principal stress space, consistent tangent operator
5. FEA of contact problem: Contact problem -- boundary nonlinearity, General contact formulation, Variational inequality and constrained optimization, Variational equation, Linearization of contact form, Friction model

6. FEA of dynamic problem (Depending on course progress): Temporal discretization; Parabolic system (heat transfer problem); Consistent mass and lumped mass, mass lumping technique; Time integration methods: explicit and implicit methods; Stability, convergence and consistency; Hyperbolic system (structural dynamics and wave propagation); Numerical dissipation and dispersion

Materials and Supply Fees

N/A

Required Textbooks and Software

- Introduction to Nonlinear Finite Element Analysis
- Nam-Ho Kim
- Springer, 2014
- ISBN-10: 1441917454

Recommended Materials

- Computational inelasticity
- J. C. Simo and T. J. R. Hughes
- Springer

Attendance Policy, Class Expectations, and Make-Up Policy

Homework is an essential part of this course. Various programming and formulation problems will be assigned on Canvas. Homework needs to be submitted on Canvas. Late homework will not be accepted.

Exams: There will be two exams during the semester. Exam will be open book and scientific calculator is allowed. There will be no final exams.

Projects: There will be two term projects. One project is related to computer implementation of hyperelasticity, and the other is solving nonlinear structural problems using Abaqus. Here the students are encouraged to learn certain aspects of the software on their own as an exercise in self-education and life long learning. Projects must be submitted by noon on Canvas. Late project will not be accepted.

Excused absences must be consistent with university policies in the Graduate Catalog (<https://catalog.ufl.edu/graduate/regulations>) and require appropriate documentation. Additional information can be found here: <https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Homework	100 each	20%
Project 1	100	20%
Exam 1	100	20%
Project 2	100	20%
Exam 2	100	20%
		100%

Grading Policy

The following is given as an example only.

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00

80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:

<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting <https://disability.ufl.edu/students/get-started/>. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To “publish” means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Conduct Code (<https://sccr.dso.ufl.edu/process/student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

All students are required to install Abaqus SE on their personal computer. It is not allowed to use lab computer for class assignments. Use the following link to download Abaqus: <http://academy.3ds.com/software/abaqus-student-edition/>. You will need the software for homework and projects. If you are familiar to other FE software (ANSYS, Nastran, etc), you can use it, but class will follow with Abaqus.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the [Office of Title IX Compliance](#), located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

COVID-19

- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email covid@shcc.ufl.edu) to be evaluated for testing and to receive further instructions about returning to campus.
- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the [UF Health Screen, Test & Protect website](#) for more information.
- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
<https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling; <https://career.ufl.edu>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: <https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>; <https://care.dso.ufl.edu>.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.