CES 5116 : Finite Elements in Civil Engineering

1. Catalog description:
Introduction to finite elements, use of finite element concepts for structural analysis. Application of 1-, 2-, and 3-D elements of structural problems, (3 credits).

2. Prerequisites/co-requisites:
CES 4141 or similar (matrix-based direct-stiffness structural analysis).

3. Course objectives:
The objectives of this course are *1*) to provide the student with an understanding of the mathematical basis of the finite element method and *2*) to provide the student with an understanding of the steps involved in creating and validating finite element analysis models; appropriately using finite element software; and interpreting analysis results.

4. Contribution to professional component (ABET):
Not applicable.

5. Relationship to program outcomes (ABET):
Not applicable.

6. Instructor:
Dr. Gary Consolazio, Office: 475-J Weil Hall, Phone: 392-9537 x1510, E-mail: GRC@CE.UFL.EDU, Class website: WWW.CE.UFL.EDU/~GRC (follow link for CES 5116), Office hours: posted next to office door.

7. Teaching assistant:
None.

8. Meeting times:
Mon., Wed., Fri., 2nd Period (8:30 am – 9:20 am)

9. Class schedule:
Three 50-minute lectures per week.

10. Meeting location:
WEI 238 (Weil Hall)

11. Material and supply fees:
Not applicable.

12. Textbooks and software:
Required course notes: Posted to course website in PDF format for printing by students.

Recommended textbook: Cook, R.D., Malkus, D.S., Plesha, M.E., Witt, R.J. *Concepts and Applications of Finite Element Analysis*, 3rd or 4th Ed., John Wiley & Sons, Inc.

Required software: MathCad (or similar) and ADINA (provided).

13. Recommended reading:
Not applicable.

14. Course Outline:

General

- Finite element concepts; modeling; discretization; element selection; testing; model validation

- Matrix operations, numeric integration (Gauss-quadrature)

Line elements (1-D), displacement DOF: Truss

- Axial line element (bar); C^0 shape functions (interpolation functions); element matrix formulation; integration; loads; assembly of global matrices; solution; force recovery; coordinate transformations
- Element matrix formulation techniques: virtual work; method of weighted residuals; variational methods; strong form; weak form; essential and natural boundary conditions; Galerkin method; Rayleigh-Ritz method

Surface elements (2-D), triangular, scalar DOF: Torsional warping

- Governing equations for torsional warping; application of the variational method; 2-D scalar DOF interpolation using triangular elements; torsional constant J; solution convergence; 2-D mesh generation

Surface elements (2-D), quadrilateral, displacement DOF: Plane stress/strain, plate, shell, axisymmetric

- Shape functions; strain-displacement relationships; constitutive relationships (stress-strain relationships, material models)
- Plane-stress, plane-strain, and axi-symmetric analysis using rectangular elements; locking; full vs. reduced integration; spurious modes; incompatible modes; stress recovery; interpretation of analysis results (principal stress, effective stress)
- Isoparametric surface element formulations; shape functions; consistent loads; effects of element distortion; stress recovery, extrapolation, and smoothing
- Plate bending elements; Kirchoff vs. Mindlin formulations; constitutive relationships; interpretation of analysis results (principal moments and shears)
- Flat shell elements; superposition of membrane and plate bending; drilling DOF
- Axisymmetric elements

Volume elements (3-D), displacement DOF: Solid

- Isoparametric volume (solid brick) elements; shape functions; constitutive relationships

Line elements (1-D), displacement DOF : Beam

Flexural line element (beam); C^1 shape functions (interpolation functions); element matrix formulation; integration; loads; assembly of global matrices; solution; force recovery; coordinate transformations

15. Attendance:
Students are expected to attend class regularly, however, attendance will not be formally recorded. Habitual tardiness will not be tolerated.

16. Grading and assignments:
Assignments: 30%, Exam 1: 35%, Exam 2: 35%

All assignments will be evaluated for overall degree of completion. A randomly selected subset of assignments will also be graded in detail. Solutions to assignments will be distributed by the instructor. Each student is responsible for comparing their solution to the solution posted by the instructor to determine if errors were made. Questions relating to the posted solutions should be brought to the instructor for clarification.

A due date and time will be indicated on each assignment. Assignments submitted late will be penalized as follows: 0-24 hrs late: 25% penalty; 24-48 hrs late: 50% penalty; 48+ hrs late : 100% penalty. Exceptions may be made in cases where the student has spoken to the instructor *prior* to the due date of the homework or cases where there is a valid excuse (e.g. medical emergency with written proof).

Assignments will consist of hand calculations, spreadsheet development, use of finite element analysis software, or a combination of any of these components. Each problem solution submitted shall begin with a statement of the problem being solved. All hand calculations must be submitted on engineering computation

paper with clear calculations, and neat sketches. Sloppy, disorganized homework will not be graded. Spreadsheets must include comments documenting the procedures being implemented, variables used, degrees of freedom chosen, etc. Where appropriate, sketches should be included either as hand drawn supplements that are referred to in the spreadsheet printouts (e.g. "see Figure 1") or as computer sketches included directly in the spreadsheet printouts. Finite element analysis problems must include a complete description of the model (overall geometry, boundary conditions, loading conditions, material properties, etc.). Print-outs of complete input files and relevant data from output files shall be included.

17. Grading scale :
A 100-93; A- 93-90; B+ 90-87; B 87-82; B- 82-80; C+ 80-77; C 77-72; C- 72-70; D+ 70-67; D 67-62; D- 62-60. Grades may be curved at the instructor's discretion.

Undergraduate students, in order to graduate, must have an overall GPA and an upper-division GPA of 2.0 or better (C or better). Note: a C- average is equivalent to a GPA of 1.67, and therefore, it does not satisfy this graduation requirement. Graduate students, in order to graduate, must have an overall GPA of 3.0 or better (B or better). Note: a B- average is equivalent to a GPA of 2.67, and therefore, it does not satisfy this graduation requirement. For more information on grades and grading policies, please visit: catalog.ufl.edu/ugrad/ current/regulations/info/grades.aspx

18. Make-up exam policy:
Make-up exams will not be given except in cases of valid medical emergencies (for which the student must provide written documentation) or certain other admissible emergencies. Students with questions regarding this policy are urged to consult the instructor.

19. Honesty statement:
Each student is expected to submit work that constitutes an independent effort on their part. While open discussion of assignments (but not exams) is acceptable and, in fact, encouraged, the written work submitted by each student must reflect that student's understanding of the topics covered. Failure to comply with this policy will result in serious consequences.

All students admitted to the University of Florida have signed a statement of academic honesty committing themselves to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action. This statement is a reminder to uphold your obligation as a UF student and to be honest in all work submitted and exams taken in this course and all others.

20. Students with Disabilities:
Students requesting classroom accommodation must first register with the Dean of Students office. That office will provide the student with documentation that he/she must provide to the course instructor when requesting accommodation.

21. UF Counseling Services:
Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:
- University Counseling Center, 301 Peabody Hall, 392-1575, personal and career counseling
- Student Health Care Center, 392-1171, mental health counseling
- Center for Sexual Assault/Abuse Recovery and Education (CARE), Student Health Care Center, 392-1161, sexual assault counseling
- Career Resource Center, Reitz Union, 392-1601, career development assistance and counseling

22. Software Use:
All faculty, staff and students of the University of Florida 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.