FAU

FLORIDA ATLANTIC UNIVERSITY

NEW COURSE PROPOSAL
Graduate Programs

Department Civil, Environmental & Geomatics Engineering

College Engineering and Computer Science

(To obtain a course number, contact erudolph@fau.edu)

UGPC Approval _____
UFS Approval _____
SCNS Submittal _____
Confirmed _____
Banner Posted _____
Catalog _____

Prefix CES **Number** 5527	*(L = Lab Course; C = Combined Lecture/Lab; add if appropriate)* **Lab Code**	**Type of Course** Lecture	**Course Title** Nonlinear Behavior of Structures

Credits *(Review Provost Memorandum)*: 3

Effective Date *(TERM & YEAR)*: Fall 2020

Grading *(Select One Option)*: Regular (●) Sat/UnSat (○)

Course Description *(Syllabus must be attached; see Guidelines)*

Course provides an introduction to the fundamental concepts used to analyze the nonlinear behavior of structures under static loading conditions. Displacements, member forces and collapse conditions are studied considering equilibrium in the deformed configuration and linear-elastic, perfectly-plastic material behavior. Assignments require the development of computer programs written in MATLAB (or Excel) and their solutions verified using the nonlinear modeling capabilities of MASTAN2.

Prerequisites	**Corequisites**	**Registration Controls** *(Major, College, Level)*
None		

Prerequisites, Corequisites and Registration Controls are enforced for all sections of course

Minimum qualifications needed to teach course:	**List textbook information in syllabus or here**
Member of the FAU graduate faculty and has a terminal degree in the subject area (or a closely related field.)	Matrix Structural Analysis, 2nd Ed., by McGuire, Gallagher, Ziemian
Faculty Contact/Email/Phone Prof. Barry Rosson/rosson@fau.edu/7-4554	**List/Attach comments from departments affected by new course**

Approved by	***Date***
Department Chair	10/17/2019
College Curriculum Chair	10/17/2019
College Dean	10/17/2019
UGPC Chair	11/6/19
UGC Chair	11/6/19
Graduate College Dean	11-13-19
UFS President	
Provost	

Email this form and syllabus to UGPC@fau.edu one week before the UGPC meeting.

GRADUATE COLLEGE
OCT 18 2019

Department of Civil Environmental and Geomatics Engineering
Florida Atlantic University
Course Syllabus

1. Course title/number, number of credit hours	
CES 5527 Nonlinear Behavior of Structures	3 credit hours
2. Course prerequisites, corequisites, and where the course fits in the program of study	
None	
3. Course logistics	
1. Students are encouraged to access Canvas each week for course information and assignments. 2. Students are required to complete all homework assignments using the Assignment Presentation format as specified in section 18 of the syllabus. 3. All communication with the instructor must be conducted via email using the students FAU email account. 4. Exams are given only at the scheduled times and places. Except for those students who have an excused absence, no make-up exams are given.	
4. Instructor contact information	
Instructor's name *Office address* *Office Hours* *Contact telephone number* *Email address*	Dr. Barry Rosson, P.E., Professor Engineering West (Bldg 36), Room 213 TBA 561-297-4554 rosson@fau.edu
5. TA contact information	
TA's name	There is no TA for the course.
6. Course description	
Course provides an introduction to the fundamental concepts used to analyze the nonlinear behavior of structures under static loading conditions. Displacements, member forces and collapse conditions are studied considering equilibrium in the deformed configuration and linear-elastic, perfectly-plastic material behavior. Assignments require the development of computer programs written in MATLAB (or Excel) and their solutions verified using the nonlinear modeling capabilities of MASTAN2.	
7. Course objectives/student learning outcomes/program outcomes	
Course objectives	1. Provide students with an understanding of equilibrium of the structure in the deformed configuration 2. Enable students to gain a better understanding of the physical behavior of linear-elastic, perfectly-plastic materials under axial, torsional and flexural loads 3. Illustrate the importance of analyzing structures under these two conditions, both separately and together 4. Enable students to compute displacements, stresses, internal forces and reactions of various types of structures and loading conditions under these two conditions 5. Introduce the concepts of residual forces, shakedown, incremental collapse and plastic collapse conditions

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Student learning outcomes & relationship to program/ ABET outcomes a-k	A. An ability to understand the mechanical properties of the inelastic materials (1,2,4) B. An ability to perform a structural analysis with inelastic material properties under axial, torsional and flexural loading conditions (1,2,4) C. An ability to perform a structural analysis of a structure in the deformed configuration (1,2,4) D. An ability to understand the importance in design of forces that create shakedown, incremental collapse and plastic collapse (1,2,4)

8. Course evaluation method

Homework Problems	30 %
Project	15%
Mid-Term Exam	25 %
Final Exam	30 %

9. Course grading scale

A	(100 – 93)	A-	(92 – 90)	B+	(89 – 87)
B	(86 – 83)	B-	(82 – 80)	C+	(79 – 77)
C	(76 – 73)	C-	(72 – 70)	D+	(69 – 67)
D	(66 – 63)	D-	(62 – 60)	F	(59 – 0)

10. Policy on exams, homework, in-class problems, excused absence, and incomplete course grade

Exams will only be given at the scheduled times. Exceptions to this policy will only be granted to students with an excused absence.

Homework will be due two weeks after being assigned. Programs are to be written using only MATLAB (or Excel). MATLAB source code (with input & output files) and executable Excel files are to be sent as attachments to rosson@fau.edu. Hand calculations must be completed on engineering paper. Students taking the course on-line are to submit scanned PDF files of their hand calculations on engineering paper. Refer to section 18 for additional requirements.

Late Homework will not be accepted unless the student has an excused absence. Late homework will be due at the earliest date the excused absence is no longer in effect.

Project will be assigned to all graduate students in the course and will require a classroom presentation. The project is meant to strengthen the student's ability to present structural engineering technical results and to enhance their understanding of the material by preparing a 15-20 minute PowerPoint presentation. A list of possible projects will be given from which each student will select their project topic and presentation.

Excused Absence: Students have the right to reasonable accommodations to participate in university approved activities, including athletic, scholastic, performance and debate activities. It is the student's responsibility to notify the instructor at least one week prior to the university-related activity. Other excused absences that preclude participation in class include an illness or injury, or a hardship that is extraordinary as determined by the instructor. When in doubt as to the severity of the hardship, and if possible to do beforehand, please seek approval by email from me prior to missing class. Confirmation from me in this way ensures there will be no doubts or confusion as to whether or not the absence will be considered excused.

Incomplete Course Grade: A student who is passing the course, but has not completed all required work due to an exceptional circumstance, may temporarily receive a grade of incomplete (I). The assignment of this grade is given at the discretion of the instructor; my policy is to give students this grade only when necessary and if the mid-term exam has been completed. The remaining work and the time-frame in which to complete the course are given at the time the (I) grade is assigned. This grade automatically becomes a failing (F) grade if all remaining work is not completed as stipulated or within a maximum 12-month period.

11. Special course requirements

None

12. Classroom etiquette policy

University policy requires that in order to enhance and maintain a productive atmosphere for education, personal communication devices are to be disabled and put away during class. Recording and camera features of your cell phone are not to be used for any reason during class. You are requested to be in your seat no later than 10 minutes after the class has begun, and to not leave until the class has ended.

13. Attendance policy statement

Students are expected to attend all of their scheduled University classes and to satisfy all academic objectives as outlined by the instructor. The effect of absences upon grades is determined by the instructor, and the University reserves the right to deal at any time with individual cases of non-attendance.

Students are responsible for arranging to make up work missed because of legitimate class absence, such as illness, family emergencies, military obligation, court-imposed legal obligations or participation in University-approved activities. Examples of University-approved reasons for absences include participating on an athletic or scholastic team, musical and theatrical performances and debate activities. It is the student's responsibility to give the instructor notice prior to any anticipated absences and within a reasonable amount of time after an unanticipated absence, ordinarily by the next scheduled class meeting. Instructors must allow each student who is absent for a University-approved reason the opportunity to make up work missed without any reduction in the student's final course grade as a direct result of such absence.

14. Disability policy statement

In compliance with the Americans with Disabilities Act Amendments Act (ADAAA), students who require reasonable accommodations due to a disability to properly execute coursework must register with Student Accessibility Services (SAS) and follow all SAS procedures. SAS has offices across three of FAU's campuses – Boca Raton, Davie and Jupiter – however disability services are available for students on all campuses. For more information, please visit the SAS website at www.fau.edu/sas/

15. Counseling and Psychological Services (CAPS) Center

Life as a university student can be challenging physically, mentally and emotionally. Students who find stress negatively affecting their ability to achieve academic or personal goals may wish to consider utilizing FAU's Counseling and Psychological Services (CAPS) Center. CAPS provides FAU students a range of services – individual counseling, support meetings, and psychiatric services, to name a few – offered to help improve and maintain emotional well-being. For more information, go to http://www.fau.edu/counseling/

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16. Code of Academic Integrity policy statement

Students at Florida Atlantic University are expected to maintain the highest ethical standards. Academic dishonesty is considered a serious breach of these ethical standards, because it interferes with the university mission to provide a high quality education in which no student enjoys unfair advantage over any other. Academic dishonesty is also destructive of the university community, which is grounded in a system of mutual trust and place high value on personal integrity and individual responsibility. Harsh penalties are associated with academic dishonesty. See University Regulation 4.001 at www.fau.edu/regulations/chapter4/4.001_Code_of_Academic_Integrity.pdf

17. Required texts/reading

None

18. Supplementary/recommended readings

Matrix Structural Analysis, 2nd Ed., by McGuire, Gallagher, Ziemian

19. Course topical outline, including dates for exams/quizzes, papers, completion of reading

Review of Virtual Work, Equilibrium in the Deformed Configuration
Linear-Elastic, Perfectly-Plastic Material Behavior
Stresses and Stiffness Reduction in Torsional and Flexural Members

Objectives	Provide students with an understanding of equilibrium of the structure in the deformed configuration, and enable them to gain a better understanding of the physical behavior of linear-elastic, perfectly-plastic materials under torsional and flexural loads, and to illustrate the importance of analyzing structures under these two conditions, both separately and together	
Outcomes	Students develop an ability to perform a structural analysis of a structure in the deformed configuration and to understand the mechanical properties of the inelastic materials, and to perform a structural analysis with inelastic material properties under axial, torsional and flexural loading conditions	
Assessments	3 Homework Problems and Mid-Term Exam	
Week 1		Review of virtual work: Calculating the displacement of trusses, beams and frames
Week 2	**HW #1**	Equilibrium in the deformed configuration: Beam-columns and trusses with linear-elastic material properties
Week 3		Equilibrium in the deformed configuration: Beam-columns and trusses with linear-elastic material properties
Week 4	**HW #2**	Linear-elastic, perfectly-plastic material behavior: Stiffness reduction of solid circular shafts in torsion
Week 5		Linear-elastic, perfectly-plastic material behavior: Stiffness reduction of rectangular beams in bending
Week 6	**HW #3**	Linear-elastic, perfectly-plastic material behavior: Stiffness reduction of steel W-shape beams in bending
Week 7		Linear-elastic, perfectly-plastic material behavior: Stiffness reduction of steel W-shape beams in bending
Week 8		Review **Mid-Term Exam**

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Collapse Conditions, Shakedown Limit Load, Residual Forces Effects of Including Axial Force With Beam Bending Combined Effects of Equilibrium in the Deformed Configuration and Material that Produces Loss of Stiffness Due to Yielding		
Objectives	Enable students to compute displacements, stresses, internal forces and reactions of various types of trusses and frames under these two conditions, and to introduce the concepts of residual forces, shakedown limit load, incremental collapse and plastic collapse conditions	
Outcomes	Students develop an ability to perform a structural analysis with inelastic material properties under axial and flexural loading conditions in the deformed configuration, and to understand the importance in design of forces that create shakedown, incremental collapse and plastic collapse	
Assessments	3 Homework Problems and Final Exam	
Week 9		Plastic collapse: Beams with distributed and concentrated loads
Week 10	**HW #4**	Plastic collapse: Beams with distributed and concentrated loads
Week 11		Effects of including axial force with bending: Stiffness reduction and plastic moments of steel W-shape sections
Week 12	**HW #5**	Combined effects: Trusses with equilibrium in the deformed configuration and linear-elastic, perfectly-plastic material behavior
Week 13		Combined effects: Steel frames with equilibrium in the deformed configuration and linear-elastic, perfectly-plastic material behavior
Week 14	**HW #6**	Incremental collapse and shakedown limit load: Beams with live loads that create residual forces and displacements
Week 15		Incremental collapse and shakedown limit load: Beams with live loads that create residual forces and displacements
Week 16		**Final Exam**

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18. Assignment Presentation (Required Format for Homework Sets)

All Homework Sets must be submitted using the following standardized format. Any assignment that does not comply with the following guidelines will not be accepted or graded. Unless specified otherwise, all handwritten Homework assignments must be submitted on 8.5" x 11" engineering paper. Computer output must be submitted on 8.5" x 11" white paper.
Staple all pages in the upper left corner.

* The following **information** must be provided:
    1. At the **top of the first page** indicate Assignment number, Course number, Student's first and last name, and first Page number/Total number of pages (Example: HW#2 CGN 4930 Barry Rosson 1/3)
    2. At the **top of all subsequent pages** indicate the Student's last name, current Page number/Total number of pages (Example: Rosson 2/3)

* All **text and computations** must be written in a clear and professional manner using the following guidelines:
    1. Solution development must follow a logical flow and labeled accordingly with proper units.
    2. Any assumptions not readily apparent from the context and subject of the problem need to be mentioned and justified – this will typically not be necessary.
    3. Points will not be given for problems with partial answers containing only a written description of the process that is to be followed to arrive at a solution.
    4. Unsuccessful attempts that do not have an answer with a box around it will not be graded – in order to receive partial credit for incorrect answers, the entire problem must be attempted and a final answer provided.
    5. Use a straight edge or CAD software for figures, with dimensions as close to scale as possible.
    6. The use of ink pens are acceptable but neatness tends to be difficult to manage; mechanical lead pencils are preferable and provide an easier alternative for submitting clear and concise solutions.
    7. Writing should be on the appropriate side of the engineering paper and only on this one side.

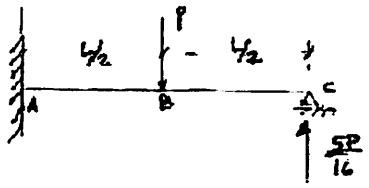
* All **graphs** must be presented in a clear and legible format:
    1. Label the x and y axes using the appropriate variable and units in parenthesis.
    2. When plotting multiple curves, provide a legend for each curve.
    3. Use an appropriate size font and reasonable dimensions for each axis.
    4. Unless printing in color, use different line types (solid, dashed, dotted, etc.).
    5. Plot the results using Excel or any other similar type of graphical output.

* All **computer programs** written in MATLAB (or Excel) must be submitted in the following format:
    1. The File Name must include the Homework Assignment Number, Problem Number, and Student's Last Name (Examples: Hw1Prob2Rosson.mat or Hw3Prob1Rosson.xlsx).
    2. MATLAB source code with variables defined and input/output files that can be easily verified.
    3. Excel programs with variables defined and input/output cells clearly delineated.
    4. Programs must follow a logical sequence of computations from one step to the other.
    5. MATLAB and Excel files are to be sent as attachments to rosson@fau.edu.

*** Example homework format**

HW #3 EGN 3131 John Doe 1/3

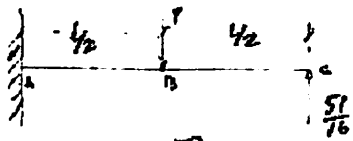
1. GIVEN:

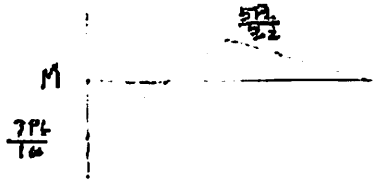


REQUIRED: 1.) Find the vertical deflection at point B.

SOLUTION:

(REAL)

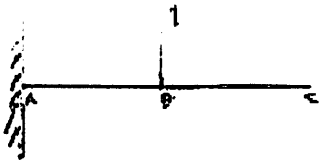




$M_{AB} = -\frac{3PL}{16} + \frac{11Px}{16}$

$M_{BC} = \frac{5PL}{32} - \frac{5Px}{16}$

(VIRTUAL)



$M_{AB} = (-1)(L/2) + (1)x$

$M_{BC} = 0$

$\sum W_c = \int U$

$\sum W_c = M_B(1) = M_B$

$$\int U = \frac{1}{EI}\int_0^{L/2}\left(-\frac{3PL}{16} + \frac{11Px}{16}\right)\left(x - \frac{L}{2}\right)dx + 0$$

$$= \frac{1}{EI}\int_0^{L/2}\left(\frac{-3PLx}{16} + \frac{3PL^2}{32} + \frac{11Px^2}{16} - \frac{11PLx}{32}\right)dx$$

$$= \frac{1}{EI}\left(\frac{-3PLx^2}{32} + \frac{3PL^2x}{32} + \frac{11Px^3}{48} - \frac{11PLx^2}{64}\right)\Bigg|_0^{L/2}$$

$$= \frac{1}{EI}\left(\frac{-3PL^3}{128} + \frac{3PL^3}{64} + \frac{11PL^3}{384} - \frac{11PL^3}{256}\right)$$

$$= \frac{1}{EI}\left(\frac{-18PL^3 + 36PL^3 + 22PL^3 - 33PL^3}{768}\right) = \boxed{\frac{7PL^3}{768EI} = M_B}$$