LAMINATED COMPOSITE MATERIALS
EML 6232
INTRODUCTION TO COMPOSITE MATERIALS
EML4230

FALL 2015

ROOM ISA3050   **(Tu Th 3:30PM-4:45PM)**

INTRODUCTION: "*Do not give them any more straw to make bricks with, as your custom has been; let them go and find straw for themselves" (Exodus 5)*. Although synthetic composites have existed for thousands of years, the high technology of advanced composites has been used in the aerospace industry only for the last fifty years. The applications are becoming diverse - from aircraft structures and missile canisters to tennis racquets and fishing rods. The objective of this course is to analyze and design structures made of fiber reinforced composite materials.

SHORT OBJECTIVES: Introduce to advanced composite materials and their applications. Develop fundamental relationships for predicting the mechanical and hygrothermal response of multi layered materials and structures. Develop micromechanical and macromechanical relationships for lamina and laminated materials with emphasis on continuous filament. Introduce material, structural, and strength optimization to design laminated composite materials using user-friendly software.

IMPORTANT URLS:
Course website
http://www.eng.usf.edu/~kaw/class/composites

Course Resources
http://www.eng.usf.edu/~kaw/class/composites/resources.html

Learning Management System (LMS) website
https://usflearn.instructure.com (Grades will be posted here)

Piazza – an online discussion board
https://piazza.com/usf/fall2015/eml4230/ (This is where everything will be posted and discussed). Postings can be done anonymously.

Email:
Send personal issues of concern to kaw@usf.edu

OBJECTIVES (letters in brackets at end of each objective correspond to a-k program outcomes of Mechanical Engineering for ABET 2000 accreditation given below):

Introduction to Composite Materials (j)
        Define a composite, enumerate advantages and drawbacks of composites over monolithic
        materials, and discuss factors which influence mechanical properties of a composite

Classify composites, introduce common types of fibers and matrices, and manufacturing, mechanical properties and applications of composites
Recycling of composites
Introduce terminology used for studying mechanics of composites

Macromechanics of a Lamina (a, e, l, n)
Review definitions of stress, strain, elastic moduli and strain energy
Derive stress-strain relationships for different types of materials
Derive stress-strain relationships for a unidirectional/bidirectional lamina
Find the engineering constants of a unidirectional/bidirectional lamina in terms of the stiffness and compliance parameters of the lamina
Derive stress-strain relationships, elastic moduli, strengths, thermal and moisture expansion coefficients of an angle ply based on those of a unidirectional/bidirectional lamina and the angle of the ply

Micromechanical Analysis of a Lamina (a, e, l, n)
Develop concepts of volume and weight fraction of fiber and matrix, density and void fraction in composites
Find the nine mechanical and four hygrothermal constants: four elastic moduli, five strength parameters, two coefficients of thermal expansion and two coefficients of moisture expansion of a unidirectional lamina from the individual properties of the fiber and the matrix, fiber volume fraction, and fiber packing
Discuss the experimental characterization of the above nine mechanical and four hygrothermal constants

Macromechanical Analysis of a Laminate (a, e, l, n)
Write the code for laminate stacking sequence
Develop relationships of mechanical and hygrothermal loads applied to a laminate to strains and stresses in each lamina
Find the elastic moduli of laminate based on the elastic moduli of individual laminas and the stacking sequence
Find the coefficients of thermal and moisture expansion of a laminate based on elastic moduli, coefficients of thermal and moisture expansion of individual laminas, and stacking sequence

Failure, Analysis and Design of Laminates (a, c, e, g, k, l, n, o)
Analyze the significance of stiffness, and hygrothermal and mechanical response of special cases of laminates
Establish the failure criteria for laminates based on failure of individual lamina in a laminate
Design laminated structures such as plates, drive shafts and thin pressure vessels subjected to in-plane and hygrothermal loads
Introduce other mechanical design issues in laminated composites

PROGRAM OUTCOMES FOR MECHANICAL ENGINEERING
The measurable outcomes expected of all graduates of the program are stated below:
a. An ability to apply knowledge of mathematics, science and engineering;

b. An ability to design and conduct experiments, as well as to analyze and interpret data;
c. An ability to design a system, component or process to meet desired needs;
d. An ability to function on multi-disciplinary teams;
e. An ability to identify, formulate, and solve engineering problems;
f. An understanding of professional and ethical responsibility;
g. An ability to communicate effectively;
h. The broad educational necessary to understand the impact of engineering solutions in a global/societal context;
i. A recognition of the need for and an ability to engage in life long learning;
j. A knowledge of contemporary issues; and,
k. An ability; to use the techniques, skills, and modem engineering tools necessary for engineering practice;
1. A knowledge of chemistry and physics with depth in both.
m. An ability to apply advanced mathematics through multivariate calculus and differential equations.
n. A familiarity with statistics and linear algebra;
o. The ability to work professionally in both thermal and mechanical systems areas including the design and realization of such systems.

OUTCOMES:
Students would have fundamental knowledge in mechanical analysis and design of structures made of composite materials

PRE REQUISITES:
Mechanics of Materials, EML 3500 or equivalent.
Computational Methods, EML3041 or equivalent.
You should have a C- or higher in both courses.

CALCULATOR: No programmable calculators are allowed in the classroom or tests. You can only use nonprogrammable calculators for class work, homework, and tests. The only acceptable calculators are **TI-30Xa** and **TI-30Xa Solar**. No other calculator is allowed. No exceptions will be made. Office Depot, Staples, and Wal-Mart stock these calculators. Bring the calculator to every class.

This model is better as it has a clearer display.
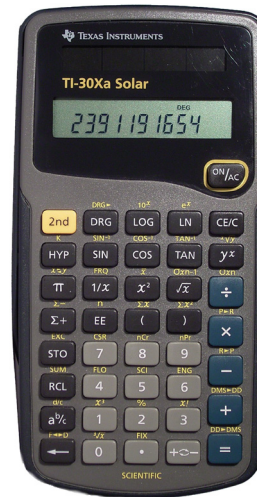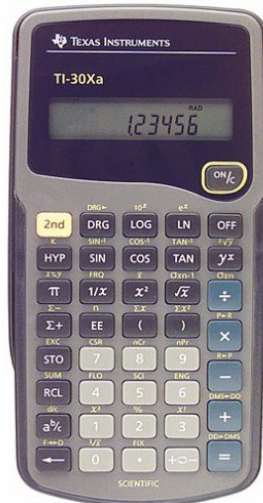
TEXTBOOK: Mechanics of Composite Materials by Autar K. Kaw, CRC-LLC Press, FL, Second Edition, 2005. **The book is available at the library for a full-semester loaner (will not be recalled) to first 40 students.**

OFFICE LOCATION: ENC 2215

E-MAIL : kaw@usf.edu

OFFICE HOURS: Tues Thurs 2-3pm
We will also discuss the course via Piazza
https://piazza.com/usf/fall2015/eml4230/

GRADING: Your final letter grade will be based on the following:
Test dates
Test 1: 20% Tuesday **September 8**
Test 2: 35% Tuesday **October 27**
Test 3: 20% Tuesday **November 24**
Comprehensive Test (Chapters 2-5 only): 25% **Thursday December 10 (12:30-2:30 PM)**
Extra credit opportunities may be given throughout the semester.

GUARANTEED GRADING POLICY:
Grade A+ is 95-100 (4.00)   Grade A is 90-94 (4.00)   Grade A- is 86-89 (3.67)
Grade B+ is 83-85 (3.33)   Grade B is 80-82 (3.00)   Grade B- is 76-79 (2.67)
Grade C+ is 73-75 (2.33)   Grade C is 70-72 (2.00)   Grade C– is 66-69 (1.67)
Grade D+ is 63-65 (1.33)   Grade D is 60-62 (1.00)   Grade D is 56-59 (0.67)
Grade F is 0-55 (0.00).

Your final grade will be rounded off as follows at the end of the course. The integer part of your course after adding 0.999999 will be recorded as your final grade. For example, 84.000001 will be rounded off as 85, and 84.0000009 will be rounded off as 84. Course grades will be evaluated on the above percentages and a letter grade will be assigned to you as outlined in the University catalog for undergraduate students (2015-2016). **Ten points will be added to every test if you signed up for EML4230.**

Course grades will be evaluated on percentage score and a letter grade will be assigned to you as outlined in the University catalog for undergraduate/graduate students (2013-2014).

COURSE SCHEDULE

TOPIC	LECTURE HOURS
CHAPTER 1	6
Introduction to Composite Materials	
CHAPTER 2	12
Macromechanical Behavior of a Lamina	
CHAPTER 3	6
Micromechanical Behavior of a Lamina	
CHAPTER 4	6
Macromechanical Behavior of a Laminate	
CHAPTER 5	8
Design and Failure of a Laminate	

All the examinations and tests stated above will be closed book and closed notes. A formula sheet made by the instructor may be allowed to be used in Tests 2, 3 and the final examination. Course grades will be evaluated on the above percentages and a letter grade will be assigned to you as outlined in the University catalog for undergraduates and graduates (2015-2016).

MAKE UP TEST POLICY: In the event of a serious illness (physician's statement documenting severity of illness required), death in the family or other legitimate, documented, verifiable emergency resulting in the absence from a schedule test, a student may be given a make-up test. Notification of absence must be given prior to the commencement of the scheduled examination or test to me. Do not presume that your reasons for missing an examination or test are acceptable unless authorization is given to you.

In the event of an emergency, it may be necessary for USF to suspend normal operations. During this time, USF may opt to continue delivery of instruction through methods that include but are not limited to: Blackboard, Elluminate, Skype, and email messaging and/or an alternate schedule. It is the responsibility of the student to monitor Blackboard site for each class for course specific communication, and the main USF, College, and department websites, emails, and MoBull messages for important general information.

REGRADING POLICY
Regrading of a test, homework, or computer project should be requested within five working days of it being returned to you. Regrading after the final grade has been assigned for the course will

be allowed only in extreme circumstances. Mistakes in the grade book entries should be rectified as soon as possible to avoid any change of grade issues. You will need a copy of all your graded tests for verification. KEEP ALL YOUR GRADED PAPERS TILL THE END OF THE COURSE.

GRADES ON THE WEB
Grades will be updated on the web (https://usflearn.instructure.com) after grading of each test.

MISSED EXAMINATIONS
NO make up tests will be given. However, in the event of a serious illness (physician's statement documenting severity of illness required), death in the family or other legitimate, documented, verifiable emergency resulting in the absence from a schedule test, each case will be evaluated separately. The decision of the instructor is final. An example of a make-up score is that if you miss a test, you may be given the same grade as another exam, and so on. Curving of make-up exam grades is at the discretion of the instructor.

Notification of absence must be given before the commencement of the scheduled examination or test to me. You need to type a professional memo (no e-mails will be accepted) about your absence addressed to me as soon as possible. Attach any documentation with it.

Do not presume that your reasons for missing an examination or test are acceptable unless authorization is given to you.

POLICY ON RELIGIOUS OBSERVATIONS
Students who need to be absent under this rule must provide written notice of date(s) to me by the second-class meeting.

POLICY ON STUDENT DISABILITY ACCOMODATIONS
"Students in need of academic accommodations for a disability may consult with the office of Students with Disabilities Services to arrange appropriate accommodations. Students are required to give reasonable notice prior to requesting an accommodation." The website is http://www.sds.usf.edu/index.htm.

ACADEMIC DISHONESTY AND DISRUPTION
If you are found cheating on any of the homework, quizzes or tests, you will get a 'FF' for the whole course, and referred to the Dean's office for further process or appeal.
Academic disruption includes excessive side talking and lack of respect for your fellow classmates and the instructor, and will be handled as per the undergraduate/graduate catalog of 2015-2016.

Chapter 1: Introduction to Composite Materials
<u>Assigned Pages</u>
All
<u>Problems assigned (All problems)</u>

Chapter 2: Macromechanical Analysis of a Lamina
<u>Assigned Pages</u>
All
<u>Problems assigned</u>
You can use any resource to do the following matrix algebra procedures:
a) Get a solution to a set of equations
b) find the inverse of a matrix
2.1
2.2-2.3 (see <u>errata sheet</u> for revised numbers)
2.6-2.19
2.20. Can use Sbar and Qbar from PROMAL
2.21. Can use MATLAB
2.22. Can use Sbar and Qbar from PROMAL
2.23. Can use MATLAB
2.24. Can use Qbar and Sbar from PROMAL.
2.25-2.26
2.27-2.28. Use the answers given in the <u>solutions document</u>. It is enough to show an
example. No need to prove the inequalities. Can use MATLAB to plot graphs.
2.29-2.30. Can use MATLAB.
2.31-2.37
2.38. Can Use MATLAB
2.41. Can use MATLAB.

Chapter 3: Micromechanical Analysis of a Lamina
<u>Assigned Pages</u>
Pages 203-239
Pages 271-295 (skip derivations of the analytical strength models but understand the inputs
in the resulting formulas on pages 277-293)
Pages 296-307
<u>Problems assigned</u>
 You can use any resource to do the following matrix algebra procedures:
a) Get a solution to a set of equations
b) find the inverse of a matrix
3.1-3.11
3.14-3.15
3.17-3.18
3.19-3.20. You can use computational systems such as MATLAB. Clearly show the inputs
and outputs of the problem in the program.
3.22-3.23. You can use computational systems such as MATLAB. Clearly show the inputs
and outputs of the problem in the program.

3.24-3.25

Chapter 4: Macromechanical Analysis of a Laminate
<u>Assigned Pages</u>
All
<u>Problems assigned</u>
You can use any resource to do the following matrix algebra procedures:
a) Get a solution to a set of equations
b) find the inverse of a matrix
4.1-4.6
4.7. Calculate Nx and Mx by hand, rest you can use MATLAB
4.8 Qbar from PROMAL
4.9-4.12
4.13. [A], [B], [D] from PROMAL. Just find Mx shared by the top ply.
4.14. You can use MATLAB
4.15. [A], [B], [D] from PROMAL
4.16-4.19. You can use PROMAL

Chapter 5: Design
<u>Assigned Pages:</u>
All
<u>Problems assigned</u>
You can use any resource to do the following matrix algebra procedures:
a) Get a solution to a set of equations
b) find the inverse of a matrix
5.1-5.5
5.6. [A], [B], [D] from PROMAL.
5.7-5.11.
5.12-5.24. You can use PROMAL