ME 5720 Mechanics of Composite Materials – Winter 2007 (Ref. No. 21284)

Instructor: Dr. Ronald F. Gibson, phone 313-577-3702, FAX 313-577-8789
e-mail: gibson@eng.wayne.edu

Class Meeting Times: TTh 3:30-5:20 PM, 0263 Manoogian Hall

Office Hours: TTh 1:30-2:30 PM, or by appointment or e-mail.

Prerequisites: ME 2400 Statics and Mechanics of Materials or equivalent plus senior standing. Due to extensive use of matrix equations, previous exposure to Linear Algebra is highly desirable.

Textbook: *Principles of Composite Material Mechanics*, R. F. Gibson, McGraw-Hill, 1994. ***Photocopies of the textbook will not be allowed in class. Such photocopies are illegal and are in violation of U. S. copyright laws.*** In addition, pdf copies of Dr. Gibson's Powerpoint lecture slides are available on the web at http://www.eng.wayne.edu/page.php?id=2001. **Note that this is not Blackboard – it is Dr. Gibson's own web site**. The slides can be downloaded chapter by chapter. It is strongly recommended that you download and print out these slides and bring them to class for reference during the lectures, or save them on your laptop and bring the laptop to the lectures. This will significantly reduce the amount of note-taking that you have to do during the lectures. Use the course outline at the end of this syllabus as a guide regarding the chapter numbers that will be covered during each lecture. These slides are being revised this semester, and the revised slides will be posted chapter-by-chapter as we progress through the course. In some cases, the revised slides for a given lecture may be posted only a day or so before the lecture, so students are advised to check the above web site frequently.

References: The following reference books are available for 2 hour check-out from the Reserve Desk at the Science and Engineering Library:

- *Composite Materials Handbook - MIL 17 (3 volumes +CD-ROM)*, Technomic Publishing Co., 1990
- *Mechanics of Composite Materials*, R. M. Jones, Taylor & Francis, 1999
- *Mechanics of Composite Materials*, R. M. Christensen, Wiley, 1991
- *Engineering Mechanics of Composite Materials*, I. M. Daniels and O. Ishai, Oxford, 1994
- *Introduction to Composite Materials*, S. W. Tsai and H. T. Hahn, Technomic Pub. Co., 1980
- *An Introduction to Composite Materials*, D. Hull, Cambridge Univ. Press, 1996
- *Analysis and Performance of Fiber Composites*, B. D. Agarwal and L. J. Broutman, Wiley, 1990

Course Learning Objectives:

(Letters in brackets refer to BSME Program Educational Outcomes A - K. Abbreviations in brackets refer to the methods of evaluation, with HW = Homework; QE = Quizzes & Exams; PC = Projects or Competitions; PR = Presentations; and RP = Reports.)

Students who successfully complete ME 5720 will be able to:

1. develop a strong understanding of the role of constituents in overall response of composite lamina (micromechanics); [A, C; QE]
2. develop a strong understanding of how a set of laminae with different orientations affect the overall laminate properties and response (macromechanics); [A, J;, QE]
3. apply these concepts to analyze and design fiber-reinforced composites for engineering applications; [A, C, F, I, J; QE]

4. analyze stresses and strains in anisotropic and orthotropic materials having both continuous and discontinuous reinforcements; [A; QE]
5. model hygrothermal effects on properties and response of composite materials; [A, C, D, G, I; QE]
6. predict composite properties based on micromechanical theories; [A, C, J; QE]
7. use Classical Lamination Theory to assess the role of individual plies on overall axial, bending and twisting deformation of laminates under applied loads, and; [A; QE]
8. use failure theories for multiaxial loading to determine if the composite will fail for known loading and use this knowledge to design failure resistant structures. [A, C, F, G, I, J, K; QE]

Expected Program Educational Outcomes (as revised on May 2, 2005):

It is expected that by the time of graduation, our BSME students will:

A. be able to understand scientific principles and apply them to the practice of engineering;
B. be able to communicate effectively;
C. possess the problem-solving skills, background, and confidence necessary to educate themselves continually throughout their careers;
D. be able to apply computers as tools for engineering;
E. be able to apply the basic principles of measurement, data analysis, and design of experiments, learned through "hands-on" laboratory experience;
F. be able to practice engineering with ethical standards and a sense of responsibility to society;
G. be able to develop creative solutions to engineering problems;
H. be able to work well as part of a team;
I. be able to apply the design process to engineering problems, including the consideration of different technical alternatives while bearing in mind cost, environmental concerns, safety, and other constraints;
J. be able, based on their first-hand design experience, to analyze, construct, test, and evaluate an engineering design, and;
K. be able to connect engineering solutions and designs with contemporary issues, and consider engineering solutions and designs in a global and societal context.

Relationship of Course Objectives to Program Educational Outcomes:
Specific Learning Objectives for this course are strongly related to BSME Program Outcomes A, C and J.
Specific Learning Objectives for this course are related to BSME Program Outcomes D, F, G, I, J and K.

Policy on Deferred Grades: An "I" grade will only be given if the student is unable to complete the course because of an emergency or health problems. A grade of "I" will only be assigned if the student is not currently failing the class and if there is not a substantial quantity of work yet to be completed. An "I" grade must be made up within one year of assignment of the grade.

Student Conduct: It is the responsibility of each student to adhere to the principles of academic integrity. Academic integrity means that a student is honest with him/herself, fellow students, instructors, and the University in matters concerning his or her educational endeavors. Thus, a student should not falsely claim the work of another as his/her own, or misrepresent him/herself so that the measures of his/her academic performance do not reflect his/her own work or personal knowledge. In this regard, cheating will not be tolerated. Cheating includes (but is not limited to) any communication (written or oral) during examinations and sharing of work, such as using the same models or computer programs or copying work. All homework and projects must be an individual effort unless specifically noted. ***STUDENTS WHO CHEAT ON ANY ASSIGNMENT OR DURING ANY EXAMINATION WILL BE ASSIGNED A FAILING GRADE FOR THE COURSE.*** Therefore avoid all appearance of improper behavior! Students who witness cheating should report the incident to the instructor as soon as possible. Students are also welcome to discuss any concerns related to cheating with Dr. Trilochan Singh, Interim Chair of Mechanical Engineering.

Grading Policy:
Grading System for Students who make a grade of C or better on each of Exams #1 and #2:

Weekly Quizzes 30%
Best of Exams 1 & 2 ...40%
Exam #3 ..... 30%
Total …… 100%

Grading System for Students who <u>do not</u> make a grade of C or better on each of Exams #1 and #2:

Weekly Quizzes…….30%
Exams #1 and #2……. 20% each
Exam #3 ……30%
Total …….. 100%

P = Total points accumulated as follows (P=100 points maximum):

For Students who make a grade of C or better on each of Exams #1 and #2:

0.3P (Based on best 6 out of 9 weekly quizzes)
+0.4P (Based on best one out of Exams #1 and #2)
+0.3P (Based on Exam #3)

For Students who <u>do not</u> make a grade of C or better on each of Exams #1 and #2:

0.3P (Based on best 6 out of 9 weekly quizzes)
0.2P (Based on Exam #1)
0.2P (Based on Exam #2)
0.3P (Based on Exam #3)

Grading Scale:

$93.3 \le P = A$
$90 \le P < 93.3 = A-$
$86.7 \le P < 90 = B+$
$83.3 \le P < 86.7 = B$
$80 \le P < 83.3 = B-$
$77.7 \le P < 80 = C+$
$73.3 \le P < 77.7 = C$
$70 \le P < 73.3 = C-$
$66.7 \le P < 70 = D+$
$63.3 \le P < 66.7 = D$
$60 \le P < 63.3 = D-$
$P < 60 = F$

Decisions on grades for borderline cases will be based on such factors as professionalism, improvement during the semester, consistency, and creativity in problem solving.
Note: For Graduate Students, grades below the C (73.3) level are considered to be failing and will be converted to an F.

Course Withdrawal Policies:

1. Using the WSU Pipeline, students can request the instructor's permission (within Weeks 5 through 15) to withdraw from a course. The instructor can approve the request by assigning one of the following withdrawal grades on Pipeline: WP withdrawal/passing (withdrawal with a passing grade earned to date), WF (withdrawal/failing), or WN (withdrawal never attended or no graded work). [University Policy]
2. If a student with a failing grade does not request permission to withdraw within Weeks 5 through 15 then he/she can only receive a grade of F. [University policy]
3. All W's will count towards a student's allowed number of substandard grades (5 overall or 1 every 24 credits, 2 in any single course), and the violation for which will result in exclusion. **Therefore, it is recommended that students make withdrawal decisions before the end of Week 4 to avoid any W-grade recorded or even before the end of Week 2 in order to receive full tuition refund.** Students should NOT have to base their withdrawal decisions on exam scores so much. [School of Engineering & ME Policy]
4. If a student feels that there are extenuating circumstances (medical, family emergency, change in work schedule) that justify the withdrawal without it counting towards the allowed number of repeats, he/she must submit a petition to the Associate Dean for Academic Affairs before the end of the semester. [School of Engineering Policy]

Weekly Quizzes: In order to be successful in this course, you should get as much practice as possible in solving problems outside of class hours. This must be done on a timely and regular basis, as a good understanding of the material covered in a particular section of this course depends heavily on an equally good understanding of the material covered in preceding sections. Problems representative of the types that you should be able to solve are given at the end of each chapter in the book. You are encouraged to work together with other students in solving these problems outside of class hours, since homework will not be collected or graded. Instead, your progress will be continuously monitored by a series of short quizzes, noted by Q1, Q2, etc in the course outline below. Some quizzes will be 20 minutes each in class, open book and closed notes (class textbook only - no other books), and some quizzes will be of the take-home type. A short quiz will be given approximately every week except for examination weeks, but the three lowest quiz grades out of nine will be dropped. There will be no make-up quizzes - any quiz missed will count as one of the three that is dropped. Quiz #1 will be a review quiz based on material covered in ME 2400 Statics and Mechanics of Materials.

Exams: Students must take Exams #1, #2 and #3 on the dates shown in the course outline below. The lower grade from Exams #1 and #2 will be dropped only if you get a grade of C or better on both exams. In other words, you may not skip an exam. Under no circumstances will the lower of the first two exams be dropped if you do not make a grade of C or better on both exams, even if you get a perfect score on one of them. Should you get a grade below C on either Exam #1 or Exam #2, each of the Exams #1 and #2 will count equally (20%) in the calculation of your final grade. Exam #3 will count as 30% of your grade in all cases. If you find that you will be unable to take an exam because of work-related travel, illness or other emergencies, you must notify the instructor before the exam and make arrangements for a make-up exam. All exams will be in class, open book and closed notes (class textbook only - no other books). Finally, the work you submit should be your own - cheating will result in a failing grade for the course.

Course Outline:

Period	Date	Topics	Articles
1	1/9	Introduction, applications, fabrication processes	1.1-1.6
2	1/11	Principle of reinforcement, Review of Mech.of Matls., **Q1** (based on ME 2400)	1.1-1.6
3	1/16	Stress-strain relations for anisotropic materials	2.1-2.6
4	1/18	Analysis of orthotropic lamina, **Q2**	2.1-2.6
5	1/23	Effective Moduli of Continuous Fiber Reinforced Lamina	3.1-3.5
6	1/25	Effective Moduli of Continuous Fiber Reinforced Lamina	3.1-3.5
7	1/30	Strength of Continuous Fiber Reinforced Lamina, **Q3**	4.1-4.3
8	2/1	Strength of Continuous Fiber Reinforced Lamina	4.1-4.3
9	**2/6**	**EXAM #1**	
10	2/8	Mechanical Testing of Composites	10.1-10.3
11	2/13	Mechanical Testing of Composites	10.1-10.3
12	2/15	Lamina Hygrothermal Behavior, **Q4**	5.1-5.4
13	2/20	Lamina Hygrothermal Behavior	5.1-5.4
14	2/22	Discontinuous Fiber Reinforced Lamina, **Q5**	6.1-6.4
15	2/27	Discontinuous Fiber Reinforced Lamina	6.1-6.4
16	3/1	Laminated Beams, **Q6**	7.1-7.2
17	3/6	Laminated Beams	7.1-7.2
18	**3/8**	**EXAM #2**	
	3/12-3/16	**SPRING BREAK**	
19	3/20	Laminated Plate Theory	7.3
20	3/22	Special Types of Laminates	7.4
21	3/27	Laminate Compliances, **Q7**	7.5
22	3/29	Hygrothermal Effects in Laminates	7.6
23	4/3	Interlaminar Stresses	7.7
24	4/5	Strength of Laminates, **Q8**	7.8
25	4/10	Strength of Laminates	7.8
26	4/12	Deflection and Buckling of Laminates, **Q9**	7.9
27	4/17	Deflection and Buckling of Laminates	7.9
28	4/19	Laminate Design – LAST CLASS	7.10
29	4/26	**EXAM #3 – DURING FINAL EXAM PERIOD 3:30 – 5:20 PM IN MANO 0263**	

Availability of Journals Containing Composites Articles:

Journal Name	WSU/SEL	DPL
AIAA Journal	X	X
Cement and Concrete Composites	X	
Composite Structures	X	
Composites Part A: Appl. Sci. & Mfg.	X	
Composites Part B: Engineering	X	
Composites Science & Technology X	X	
Computers and Structures	X	
Experimental Mechanics	X	X
Experimental Techniques	X	X
International Journal of Fracture	X	X
International Journal of Solids & Struct.	X	
Journal of Advanced Materials	X	X
Journal of Applied Mechanics	X	X
Journal of Composite Materials	X	X
Journal of Engr. Matls. & Technology	X	X
Journal of Materials Science		X
Journal of Reinforced Plastics & Comp.	X	

Journal of Testing and Evaluation	X	X
Polymer Composites	X	
Polymers and Polymer Composites	X	
SAMPE Journal	X	X

WSU/SEL = WSU Science and Engineering Library
DPL = Detroit Public Library

For computer-aided literature searches, you may use the WSU Library Catalog system at the web site http://elibrary.wayne.edu. Many of the journals listed above are available in electronic format. To find out if the journal is available electronically, type the journal name in the keyword search box at http://elibrary.wayne.edu. The ISI Web of Science is particularly useful for literature searches, and may be accessed by typing the words *Web of Science* in the keyword search box at http://elibrary.wayne.edu. The Engineering Village is another very useful search engine which can be accessed by typing the words *Engineering Village* in the keyword search box at http://elibrary.wayne.edu.

Composites Web Sites:

Name	**Web address**
American Society for Composites	http://www.asc-composites.org
E-Composites.com	http://www.E-Composites.com/
Worldwide Composites Search Engine	http://www.wwcomposites.com/
NetComposites	http://www.netcomposites.com
Glossary of Composite Terms	http://www.fiberset.com/html/glossary/glos_a.htm
The Composites News Supersite	http://www.compositesnews.com/
About Composites	http://composite.about.com/industry/composite/
Composite Oracle	http://www.composite-oracle.com