

**VILLANOVA UNIVERSITY  
MECHANICAL ENGINEERING DEPARTMENT**

ME 7501  
Reinforced Composite Materials

Spring 2020  
Dr. B.J. Sullivan

COURSE OBJECTIVE

The primary objective of this course is to present the analytical methods for the prediction of the mechanical and thermal properties of composite materials, based on the properties of their constituents. The unique properties of composites and their influence on material and structural design will also be discussed. This course emphasizes fundamental concepts as well as practical information and methods used on composite materials currently in use in industry.

TENTATIVE COURSE OUTLINE

Lecture	Date	Topic	Supplementary Readings
1	13 Jan	Introduction to Composite Materials; Background from the Theory of Elasticity	Christensen 1-30
2	27 Jan	Elasticity (cont'd); Introduction to & Basic Concepts of Micromechanics	Christensen 31-472
3	3 Feb	Elastic Properties of Particle Reinforced Composites	Christensen 47-70; Christensen 100-105;
4	10 Feb	Elastic Properties of Unidirectional Composites	Christensen 73-83; Christensen 106-124
5	17 Feb	Thermal Properties of Unidirectional Composites	Christensen 311-325
6	24 Feb	Tensile Strength of Unidirectional Composites	Christensen 149, 186,199
	2 Mar	<b>MID-TERM EXAM electronic distribution – no class</b>	
7	9 Mar	Compressive Strength of Uni Composites; Strength under Combined Stresses; Distribution and Discussion of Class Project	Christensen 199-221
		<b>Mid-Term Exam electronic solutions are due by 6:00 pm</b>	
8	16 Mar	Laminated Composites, Lamination Theory; Properties of Symmetric Laminates	Christensen 152-167
9	23 Mar	Properties of Unsymmetric Laminates; Laminate Thermal Properties; Laminate Stress Analysis	Christensen 167-186
10	30 Mar	Laminate Thermal Stress Analysis; Strength and Failure of Laminated Composites; Introduction to Composite Sandwich Structures	Notes and handouts
11	6 Apr	Fatigue of Composite Materials	Notes and handouts
12	13 Apr	Numerical Solution Methods in the Mechanics of Composite Materials	Notes and handouts
13	20 Apr	Mechanical and Thermal Properties Characterization Testing of Composite Materials <b>Electronic Submission of Course Projects due by 6:00 pm; Final Exam electronic distribution</b>	Notes and handouts
14	27 Apr	<b>FINAL EXAM – hard copy solutions are due in class at 6:00 pm</b>	

## COURSE CONDUCT

### Course Materials

Before and after each class, electronic versions of course materials will be available to the students by accessing the website <http://vucoe.drbrriansullivan.com/me-7501/>.

### Homework Assignments

Homeworks will be assigned but not collected or graded, due to the high number of student registered for this class. Homework solutions will be made available to the students for self-assessment purposes. To assist the students in keeping up with the homework and supplementary readings, weekly quizzes will be conducted/

### Quizzes

A take-home quiz will be distributed each week, which will be a question similar to but different from the homework assignment, or based on the lecture notes or supplementary readings. All students must return the quiz with their solution electronically by 6 p.m. of the following week. The weekly quiz will be open notes, open book format.

### Examinations

All exams are take-home, open book and open notes examinations.

The Mid-Term and Final examination will be provided to the students electronically no later than one week before the student solutions are due. All students (Sections 001 and DL1) must submit their exam solutions in electronic format.

### Course Text

There is no single text book which treats each of the above topics in exactly the same way as they will be covered in this course, or which places the exact same emphasis on the topics as will be placed on them in this course. Consequently, class notes developed by the students from the lectures and including handouts provided by the instructor, supplemented by regularly assigned homework problems, will form the primary source of information. The text book which will be used in the class is

R.M. Christensen, Mechanics of Composite Materials, Dover Edition, Dover, 2005, ISBN 0-48644-239-X.

It is suggested that the students refer to any of the following books for supplementary material:

Ronald f. Gibson, Principles of Composite Material Mechanics, 3<sup>rd</sup> Edition, CRC Press, Taylor & Francis Group, Boca Raton, FL, 2012, ISBN 978-1-4398-5005-3,

R.M. Jones, Mechanics of Composite Materials, Second Edition, Taylor & Francis, New York, NY, 1999, ISBN 1-56032-712-X.

J.C. Halpin, Primer on Composite Materials: Analysis, Technomic Publishing Co., Inc., Lancaster, PA, Second Revised Edition, 1992. ISBN 0-87762-754-1.

Engineered Materials Handbook, Vol. 1: Composites, ASM International, 1987.

M.M. Schwartz, Composite Materials Handbook, McGraw Hill, Second Edition, 1992.

G. Lubin, Editor, Handbook of Composites, Van Nostrand Reinhold Company, 1982.

Aerospace Composites: A Design & Manufacturing Guide, Gardner Publications, Inc., 2008.

R. Talrega, Fatigue of Composite Materials, Technomic Publishing Co. Inc., Lancaster, PA, 1987, ISBN 87762-516-6.

I.S. Sokolnikoff, Mathematical Theory of Elasticity, McGraw-Hill Book Company, Inc., 2nd Edition, 1956.

Selected technical papers from the literature of Composite Materials will also serve as an important source of information in this course. As appropriate, these papers will be referenced and distributed.

The final course grade will be determined on the following basis:

Quizzes	10%
Course Project	30%
Mid-Term Examination	30%
Final Examination	30%

The scale used to assign letter grades is:

Letter Grade	Numerical Grade
A	94 to 100
A-	90 to 93
B+	86 to 89
B	83 to 85
B-	80 to 82
C+	76 to 79
C	73 to 75
F	below 73

#### INSTRUCTOR AVAILABILITY

The best way to contact me is via email. My e-mail address is [brian.sullivan@villanova.edu](mailto:brian.sullivan@villanova.edu). I will respond as promptly as possible. Students may arrange to meet with me after class by requesting such a meeting via email in advance.

COURSE PROJECT

One course project will be assigned to the students during this course. An example of a course project is provided in the table below.

Description	Due Date
Design of a satellite bus structure panel of minimum weight composite sandwich structure, with in-plane zero coefficient of thermal expansion and meeting minimum natural frequency requirement; other performance metrics (FOD damage tolerance, minimum adjacent ply angles, maximum fatigue life, etc.) will be provided	One week before Final Exam due date

Complete descriptions of the assigned Class Projects will be provided to the students no later than the due date for the Mid-Term Exam solutions.

The preferred file for the submission of the course project is Microsoft PowerPoint. The format to be used by the students in the preparation of their Class Project report is the following:

- A cover page slide providing the title of the report and the name of the student.
- A brief introductory section providing some background on the nature of the topic.
- A short section describing the objective of the course project.
- A section describing the technical approach used by the student, including key equations. This portion of the report should also describe where the equations were obtained and how they were used in the study.
- A section describing results obtained by the students. The use of graphs and tables, sequentially numbered and containing appropriately descriptive captions, should be freely used in this section.
- A section summarizing the principal conclusions of the research project.
- References used in the performance of the class project can be placed at the end of the report, or can be cited as footnotes and appear at the bottom of selected, specific slides.
- Any other materials deemed sufficiently important to be included in the PowerPoint file, but perhaps too detailed to be included in one of the above sections, should be contained in a Back-Up Slides section of the PowerPoint file. *A perfect example of this is calculations performed by the student, either by hand, Mathcad, Excel, etc. Such calculations should be converted to Adobe Acrobat (i.e., pdf) format and inserted onto the back-up slides.*