MSE 556 (651) Summer I 2019 Composite Materials

Syllabus

Instructor: Jag Kasichainula, Jag_kasichainula@ncsu.edu Room: 3056 Engineering Building I

Class Hours: Mondays and Wednesdays: 11:45 AM to 1:00 PM
OFFICE HOURS: Mondays and Wednesdays : 10:30 to 11:30 AM or any time needed. You may also send an e-mail or reach me by message board.

EOL Participants may reach me from 5 to 7 PM by e-mail or message board or by calling on 919-513-3021. Please inform be before hand that you will be calling me so that I will remain in the Lab during that time.

DISCLAIMER: Information in this syllabus is subject to changes and the possession of it does not ensure that you have all the correct information required to successfully complete the semester. Announcements of changes will be made and students are responsible for obtaining additional information by attending class.

Course description:
An introduction to the theory of composites materials.

Prerequisite(s):Mechanical Properties of materials, MSE 420

Textbook(s) and/or other required material: See Introduction

Course objectives:

Students completing this course should be able to:

- **Describe the structure-property relationships for metal, ceramic and polymer matrix composites**
- **Calculate average properties for simple composite structures**
- **Describe methods used to process metal, ceramic and polymer matrix composites**
- **Design or select a specific type of composite for a particular application**

Course overview

This course covers the basic principles underlying properties of composite materials as related to the properties of individual constituents and their interactions. Polymer, metal and ceramic matrix composites are included. Property averaging and micromechanics of composites are covered at an introductory level. Emphasis is placed on design and processing of composite systems to yield desired combinations of properties. Credit for both MSE 456 and MSE 556 is not allowed.

Policies and Procedures: Visit the course site on Policies

Handicapped participants: Visit the course site on Policies

Course contents at EOL website: Please use the link below to reach the course contents available in the EOL course site

https://www.engineeringonline.ncsu.edu/course/mse-556-composite-materials/?display=course-home

Syllabus (Daily) for regular semester (for summer session see further below). The chapter number given below is from the course website (wolfware.ncsu.edu or moodle site) and not from the EOL lecture notes.

Lecture #	Date	Chapter in the Class Notes	Objective
1	01/07	Ch.1	Introduction to composites **Ch. 1 and 2**
2	01/09	Ch. 2	Elastic behavior of materials**, Ch. 1 and 2**
3	01/14	Ch. 3	Constitutive equations,**Ch. 3**
4	01/16	Ch. 3	Elastic constants of Orthotropic lamina,**Ch.3**
5	01/23	Ch. 4	Elastic constants of laminates,**Ch. 4**
6	01/28	Ch. 4	Transformation of Elastic constants of laminates,**Ch. 4**
7	01/30	Ch. 5	Thermal and moisture effects,**Ch. 5**

8	02/04	Ch. 6	Response of the laminates to applied loads-A,B,D matrices,**Ch. 6**
9	02/06	Ch. 6	Response of the laminates to applied loads-A,B,D matrices,**Ch. 6**
10	02/11	Test 1	Test on material upto Ch.5
11	02/13	Ch. 7	A,B, and D of Laminates,**Ch. 7**
12	02/18	Ch. 8	Thermal loads and Resulting Stresses,**Ch. 8**
13	02/20	Ch. 10	Failure Theories of composites,**Ch. 10**
14	02/25	Ch. 11	Micromechanics,**Ch. 11**
15	02/27	Ch. 12	Micromechanics,**Ch. 12**
16	03/04	Ch. 13	Microstructural features,**Ch. 13**
	Spring break March 11-15		
17	03/06	Ch.14	Methods of evaluation of properties,**Ch. 14**
18	03/18	Ch. 15	Thermal stresses in composites,**Ch. 15**
19	03/20	Ch. 16	Load transfer mechanisms,**Ch. 16**
20	03/25	Test 2	Test 2 Test on Ch. 6 to Ch. 14
21	03/27	Ch. 17	Stress-strain diagrams,**Ch. 17**
22	03/27	Ch. 18	Critical aspect ratio,**Ch. 18**
23	04/01	Ch. 19	Interface engineering,**Ch. 19**
24	04/03	Ch. 20	Fiber toughening,**Ch. 20**
25	04/08	Ch. 21	Statistical analysis of composites,**Ch. 21**
26	04/10	Ch. 23	Processing of composites,**Ch. 23**
27	04/15	Test 3	Test 3 on Ch. 15 to 23
28	04/17	Ch. 23	Processing of composites,**Ch. 23** Applications of composites, **Ch. 22**
29	04/22	Ch. 23	Applications of composites, **Ch. 22**

	04/24		
Final Exam	04/29		Final- Covers all material

For summer semester

Reading #	Date	Chapter in the Class Notes (This course website and not the video lectures)	Objective
1	05/15 (week 1)	Ch.1	Introduction to composites **Ch. 1 and 2**
		Ch. 2	Elastic behavior of materials**, Ch. 1 and 2**
2	05/20(week 2)	Ch. 3	Constitutive equations,**Ch. 3**
		Ch. 3	Elastic constants of Orthotropic lamina,**Ch. 3**
3	05/20 (week 2	Ch. 4	Elastic constants of laminates,**Ch. 4**
		Ch. 4	Transformation of Elastic constants of laminates,**Ch. 4**
4	05/28 (week 3)	Ch. 5	Thermal and moisture effects,**Ch. 5**
5	05/28 (week 3)	Ch. 6	Response of the laminates to applied loads-A,B,D matrices,**Ch. 6**
6	06/03 (week 4)	Ch. 6	Response of the laminates to applied loads-A,B,D matrices,**Ch. 6**
	06/06 (week 4)	Test 1	Test on material upto and including Ch.5
7	06/10 (week 5)	Ch. 7	A,B, and D of Laminates,**Ch. 7**
8	06/10 (week 5)	Ch. 8	Thermal loads and Resulting Stresses,**Ch. 8**
9	06/17 (week 6)	Ch. 10	Failure Theories of composites,**Ch. 10**
10	06/17 (week 6)	Ch. 11	Micromechanics,**Ch. 11**
11	06/17 (week 6)	Ch. 12	Micromechanics,**Ch. 12**
12	06/24 (week 7)	Ch. 13	Microstructural features,**Ch. 13**
		Ch. 14	Methods of evaluation of properties,**Ch. 14**

13	06/27 (week 7)	Ch. 16	Load transfer mechanisms,**Ch. 16**
14	07/01 (week 8)		Test 2 Test on Ch. 6 to Ch. 14 (both inclusive)
15	07/01 (week 8)	Ch. 17	Stress-strain diagrams,**Ch. 17**
		Ch. 18	Critical aspect ratio,**Ch. 18**
16	07/08 (week 9)	Ch. 19	Interface engineering,**Ch. 19**
		Ch. 20	Fiber toughening,**Ch. 20**
17	07/11 (week 9)	Ch. 22	Applications of composites, **Ch. 22**
		Ch. 23	Processing of composites,**Ch. 23**
18	07/15 (week 10)	Ch. 23	Processing of composites,**Ch. 23**
Test 3	07/22	Ch. 23	Chapters 17 to 23**(both inclusive)**
Final Exam	07/29-07/30		Final- Covers all material

Chapter titles:

Ch1. Introduction to Composites

Ch2. Elastic Behavior of materials

Ch3.Constitutive Equations of an Othotropic Lamina

Ch4. Elastic constants of laminates

Ch.5 Temperature and Moisture Effects

Ch6. Deformation of Stacked Lamina

Ch7.General Constitutive Equation for a Laminate

Ch8.Thermal Loads and Resultant Stresses

Ch9.Failure Theories of Composites

Ch10.Failure Theories-Biaxial Loads and Buckling

Ch11.Micromechanics

Ch12.Transport Properties

Ch13.Microstructural features: Density and voids

Ch14.Methods of Evaluation of Properties of Lamina

Ch15.Thermal stresses in composites

Ch 16.Load Transfer Mechanisms

Ch17.Stress-Strain diagrams for composites

Ch 18.Experimental Evaluation of critical aspect ratio

Ch 19.Interface Engineering

Ch20.Fiber Toughnening

Ch21.Statistical Analysis of Fiber and Composite Strength

Ch22.Applications of Composites

Ch23. Processing of composites

Topics of Syllabus

1. Anistropic behavior of composite materials
a. Orthotropic and specially orthotropic behavior of lamina
b. Transformation of stresses, strains, and moduli
c. Compliance (S) and stiffness matrix (Q) of the lamina, and shear coupling
d. Thermal loads and moisture effects
2. Laminate theory
a. A, B, and D matrix of the laminates
b. Types of laminates and their A, B, and D matrices and response to applied loads and moments
c. Evaluation of stresses in the laminates subjected to thermal and applied loads
3. Failure theories of the lamina
a. Maximum stress, maximum strain, Tsai-Hill, and Tsai-Wu theories, Failure under buckling
4. Failure of the laminate

a. Mechanical behavior of the laminate-linear and bilinear behavior
5. Micromechanics of composites
a. Averaging of the moduli, thermal and transport properties
b. Halpin-Tsi and Halpin-Tsai-Kardos equations
6. Load transfer mechanisms
a. Critical aspect ratio
b. Minimum and critical volume fractions of fibers.
c. Thermal stresses in composites
7. Interface engineering
a. Interface shear strength and relation to fracture strength
b. Coatings to improve the adhesion and bonding between fiber and matrix
8. Process of composites
a. Processing fibers, matrix, and composites
b. Novel methods of processing composites
9. Fracture toughness of the composites
a. Fiber pull-out, crack branching and crack bridging, fatigue of composites
b. Energy contributions from pull-out, bridging, and debonding
b. Transformation toughening
c. Statistical analysis of composite failure
10. Applications of composites
11. Processing of composites