MECH 515: Composites

Midterm 1

Take home exam – Due on October 30th, at 6:00 PM.

Please **DO NOT** communicate in any shape or form. This is an individual exam and I will take it very seriously if I find out any means of academic dishonesty.

i. A question on topic 1, Introduction to Basic Materials, (20 points).

ii. Three questions on topic 2, Overview of Composites. The first one is 29 true/false questions, (30 points); the second one and third one are numerical problems, (20 points).

iii. A question on topic 3 and 4, Fibers and Matrices, (10 points).

iv. A question on topic 7, the laminate code, (10 points).

v. Three questions on topic 7, (30 points).

vi. A question on topic 3, (10 points).

The total points are out of 130.

NAME _____

I.

_____ 1. You need to select a material for a wire that will efficiently transfer electrical charge from an electrical outlet to your computer; you would most likely select a

a. polymer b. semiconductor c. metal d. ceramic

_____ 2. You need to select a material for an integrated circuit that will have an electrical conductivity that can be varied significantly by changing the temperature or even small differences in the material's composition; you would most likely select a

a. polymer b. semiconductor c. metal d. ceramic

_____ 3. You need to select a material for an electrical component that will serve as an electrical insulator, even at high temperatures; you would most likely select a

a. polymer b. semiconductor c. metal d. ceramic

_____ 4. You would like to select a material that has both high strength and good ductility, or formability; you would most likely select a

a. polymer b. semiconductor c. metal d. ceramic

_____ 5. For the insulation on an electrical wire, you would like to select a material that will provide good electrical insulation, but will also have reasonable ductility; you would most likely select a

a. polymer b. semiconductor c. metal d. ceramic

_____ 6. The weakest of the atomic bonding mechanisms is the

a. metallic bond b. ionic bond
c. covalent bond d. van der Waals bond

_____ 7. We expect to have the highest electrical conductivity in a material that has the

a. metallic bond b. ionic bond
c. covalent bond d. van der Waals bond

_____ 8. Electrical charge is transferred by the movement of entire atoms rather than just by movement of electrons when the material possesses primarily the

a. metallic bond b. ionic bond
c. covalent bond d. van der Waals bond

_____ 9. Two different types of elements, having very different electronegativities, are normally required in order for the material to possess the

a. metallic bond b. ionic bond
c. covalent bond d. van der Waals bond

_____ 10. Bonding is particularly directional, that is there are fixed angles between the bonds, when the material possesses the

a. metallic bond b. ionic bond
c. covalent bond d. van der Waals bond

_____ 11. Atoms move past one another, causing deformation, most easily when a force is applied to the material when the material possesses the

a. metallic bond b. ionic bond c. covalent bond

_____ 12. Bonding within the chains of a polymer is due primarily to

a. metallic bonds
b. ionic bonds
c. covalent bonds
d. van der Waals bonds

_____ 13. Bonding between the chains of a thermoplastic polymer is due primarily to

a. metallic bonds
b. ionic bonds
c. covalent bonds
d. van der Waals bonds

_____ 14. A very high bonding energy between the atoms is expected to

a. provide a very stiff (high modulus of elasticity) material
b. provide a low stiffness (low modulus of elasticity) material
c. have no effect on the stiffness of a material

_____ 15. A very high bonding energy between the atoms is expected to

a. provide a material with a high coefficient of thermal expansion (that is, a large change in dimensions when the temperature changes)
b. provide a material with a low coefficient of thermal expansion (that is, a small change in dimensions when the temperature changes)
c. have no effect on the coefficient of thermal expansion

_____ 16. Based on atomic bonding, we expect the electrical conductivity of a material to decrease when the temperature increases if the material possesses

a. metallic bonds b. ionic bonds c. covalent bonds

_____ 17. We would expect the typical metal to

a. have good electrical and thermal conductivity but poor ductility
b. have good electrical and thermal conductivity and good ductility
c. have poor electrical and thermal conductivity and poor ductility
d. have poor electrical and thermal conductivity but good ductility

_____ 18. We would expect the typical ceramic to

a. have good electrical and thermal conductivity but poor ductility
b. have good electrical and thermal conductivity and good ductility
c. have poor electrical and thermal conductivity and poor ductility
d. have poor electrical and thermal conductivity but good ductility

_____ 19. Most airplanes contain large amounts of aluminum and small amounts of iron and steel; the primary reason for this is:

a. aluminum is stronger than steel
b. aluminum has a higher density than steel
c. aluminum has a higher strength-to-weight ratio than steel

_____ 20. Ceramic materials such as SiO_2 typically contain anions and cations. We would generally expect that

a. the anions have a larger radius than the cations
b. the cations have a larger radius than the anions

II. (

T F 1. We expect whiskers to have higher strengths than fibers.

T F 2. Boron fibers are generally produced by a chemical vapor deposition technique.

T F 3. PAN, or polyacrylonitrile, polymer fibers are a common precursor for carbon fibers.

T F 4. When carbonizing of a polymer fiber into a carbon fiber is done at higher temperatures, the strength increases but the modulus of elasticity decreases.

T F 5. Carbon-carbon composites are rather unique in that they typically become stronger as the temperature increases.

T F 6. Composite materials composed of continuous fibers are <u>usually</u> considered to be relatively brittle materials.

T F 7. One of the functions of the matrix is to keep the fibers in alignment while transferring any applied load uniformly to the fibers.

T F 8. Because the matrix, particularly in metal and polymer matrix composites, is more ductile than the fibers, any crack that forms in the fibers is arrested by the matrix and cannot propagate.

T F 9. Polymer matrix composites are limited to lower temperature applications than are metal or ceramic matrix composites.

T F 10. Kevlar fibers are often used to reinforce metal matrix composites.

T F 11. Poor bonding between the fibers and the matrix makes it more difficult to transfer load to the fibers and causes poor strength in metal and polymer matrix composites.

T F 12. Sizing of glass fibers means separating the fibers into groups according to their length and diameter.

T F 13. Ceramic-Ceramic composites require particularly good bonding between the fibers and the matrix if good toughness is to be achieved.

T F 14. Advanced composites containing Kevlar fibers have exceptionally good toughness.

T F 15. In a hybrid composite, a fiber reinforces a matrix composed of more than one material.

T F 16. One of the limitations of a metal matrix composite compared to a polymer matrix composite is that the metal matrix composites usually have a high density.

T F 17. Tows are individual filaments of a metal, ceramic, or polymer.

T F 18. A yarn is a bundle of thousands of filaments twisted together.

T F 19. Rovings are bundles of thousands of nontwisted filaments.

T F 20. Prepregs are tapes or fabrics of fibers impregnated with a polymer resin that are not completely polymerized.

T F 21. Composites containing chopped fibers rather than continuous fibers are more likely to have isotropic behavior.

T F 22. Most high performance composites contain more than 90% fibers by volume.

T F 23. Increasing the length of a fiber means that there is less of a chance that critically-sized flaws will be present on the fiber surface.

T F 24. Fibers with a large aspect ratio typically give a higher strength composite.

T F 25. Composites built up from tapes containing unidirectionally-aligned fibers typically perform well even when three- dimensional stresses are applied.

T F 26. Delamination may occur when individual tape or fabric layers are poorly bonded.

T F 27. Pull-out may occur when fibers are poorly bonded to the matrix.

T F 28. Whiskers are nearly perfect single crystals having a relatively small aspect ratio.

T F 29. Borsic fibers are really a composite fiber containing tungsten, boron, and silicon carbide.

Assume that the composite described in Problem 16.8 has a cross-sectional area of 320 mm^2 (0.50 $in.^2$) and is subjected to a longitudinal load of 44,500 N (10,000 lb_f).

(a) Calculate the fiber–matrix load ratio.

(b) Calculate the actual loads carried by both fiber and matrix phases.

(c) Compute the magnitude of the stress on each of the fiber and matrix phases.

(d) What strain is experienced by the composite?

A continuous and aligned fiber–reinforced composite having a cross-sectional area of 1130 mm^2 (1.75 $in.^2$) is subjected to an external tensile load. If the stresses sustained by the fiber and matrix phases are 156 MPa (22,600 psi) and 2.75 MPa (400 psi), respectively; the force sustained by the fiber phase is 74,000 N (16,600 lb_f); and the total longitudinal strain is 1.25×10^{-3}, determine

(a) the force sustained by the matrix phase,

(b) the modulus of elasticity of the composite material in the longitudinal direction, and

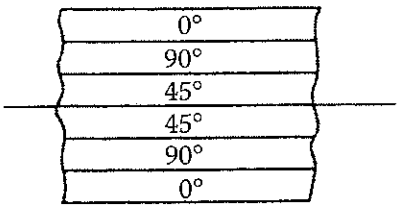
(c) the moduli of elasticity for fiber and matrix phases.

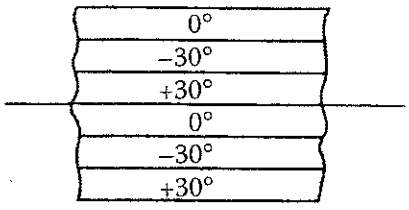
III.

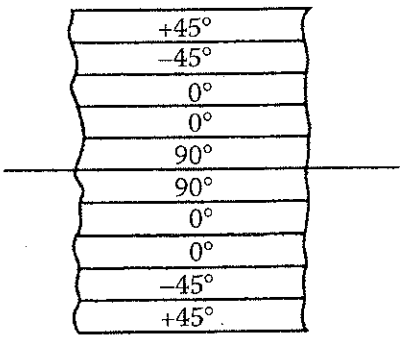
. Why are prepregs so important in polymer matrix composites? What are their advantages? Describe the different types of prepregs.

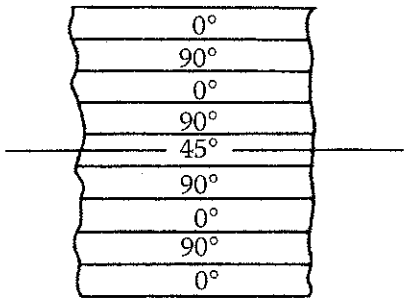
. Describe the major differences in the processing of composites having a thermoset matrix and those having a thermoplastic matrix.

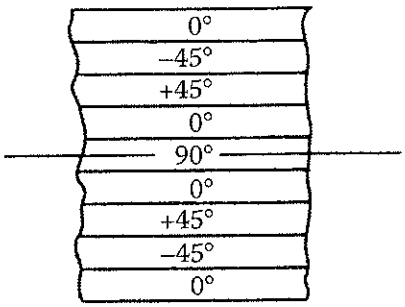
IV: Write the laminate code for the following:

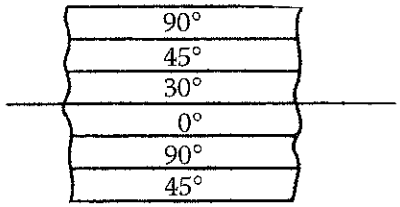












V.(a)

A two-ply laminate composite has the top and bottom ply orientations of 45° and 0° and thicknesses of 2 and 4 mm, respectively. The stiffness matrix for the

$$[Q_{ij}] = \begin{bmatrix} 20 & 1 & 0 \\ 1 & 3 & 0 \\ 0 & 0 & 1 \end{bmatrix} \text{GPa}.$$

Find the $[\bar{Q}_{ij}]_{45}$ and then compute the matrices $[A]$, $[B]$, and $[D]$ for this laminate.

V. (b)

Determine the stiffness matrix for a [+45/–45/–45 +45] symmetric angle-ply laminate consisting of 0.25-mm thick unidirectional AS/3501 carbon/epoxy laminae. An exploded view of the laminate is shown in figure

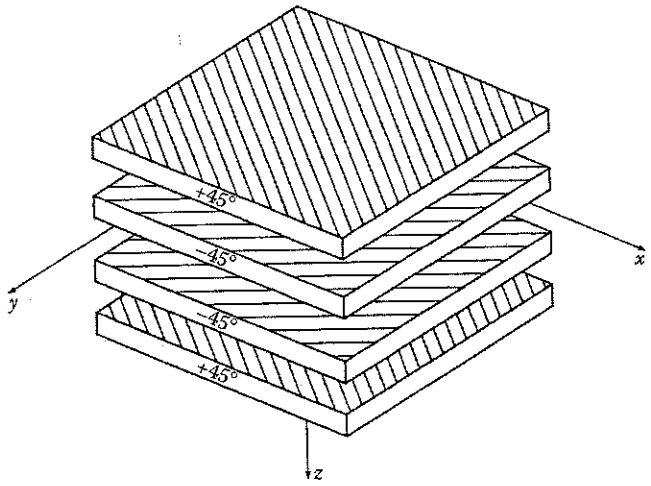


FIGURE
Exploded view of [+45/–45/–45/+45] symmetric laminate.

V. (c)

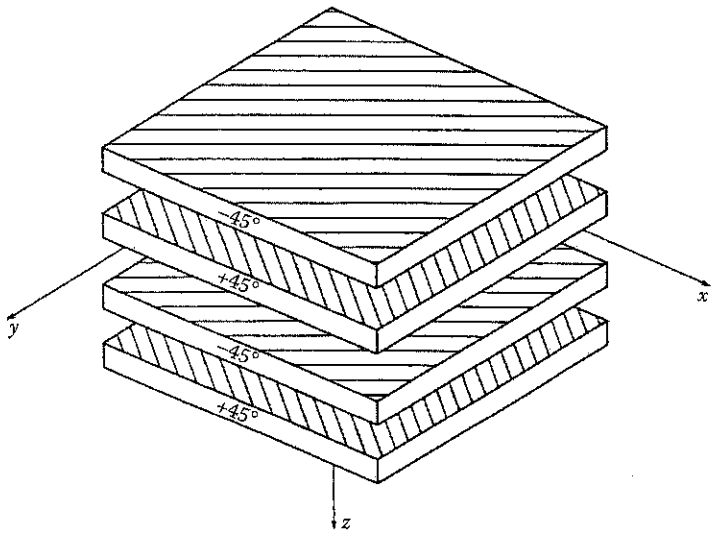


FIGURE 7
Exploded view of [−45/+45/−45/+45] antisymmetric laminate.

Determine the stiffness matrix for a [−45/+45/−45/+45] antisymmetric angle-ply laminate consisting of the same 0.25-mm thick unidirectional AS/3501 carbon/epoxy laminae that were used in V (b) *. An exploded view of the laminate is shown in figure*

VI. Enumerate the various phenomena which can cause microcracking in a fiber composite.