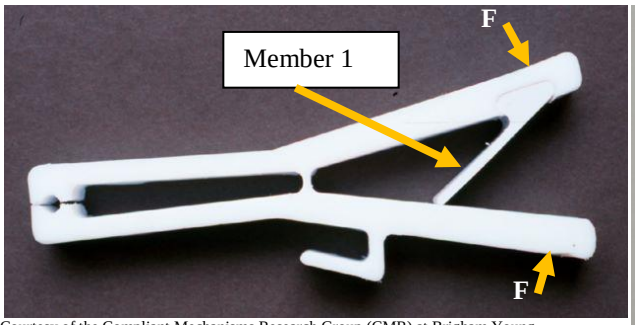
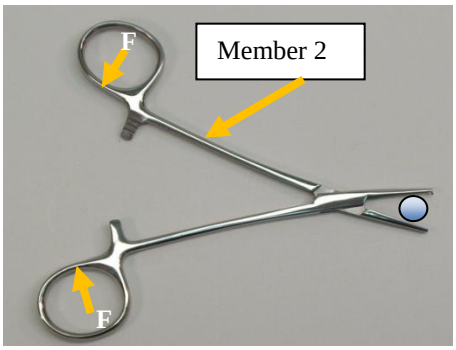
Due Th 1/29/09 **ME ID _____**

READING QUESTIONS 5 Deflection in beams, torsion

1) Compliant mechanisms are flexible mechanisms that transfer an input force or displacement to another point through elastic body deformation. These are usually single-piece, jointless structures with certain advantages over the rigid-body, or jointed, mechanisms. Shown below are two hemostats. The hemostat on the left, is a new, compliant, jointless hemostat, and the one on the right, is a traditional, pin-jointed hemostat.





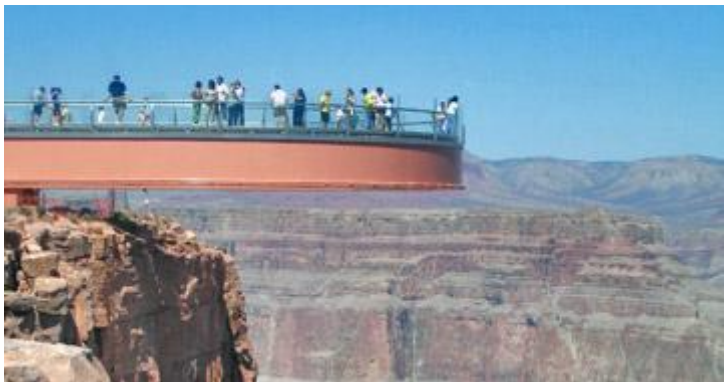
Courtesy of the Compliant Mechanisms Research Group (CMR) at Brigham Young University.

a) Can an equation from Appendix D be used to find the deflection of member 1? If so, which one? If not, explain why. No, these equations are only valid for small deflections, which is not a limitation in most cases of beam design for machine or structural applications. Sometimes beams are used as springs (as in Member 1), and their deflections may then exceed the limitations of these equations. Spring design will be covered in a later chapter.

b) Can an equation from Appendix D be used to find the deflection of member 2? If so, write the equation (simply copy one from the book). If not, explain why. Yes, Member 2 can be modeled as an overhung beam with concentrated loading. The deflection equation listed in column (a) on page 954 can be used.

2) As we learned in lecture, two design criteria are strength and stiffness. Which of these is associated with deflection? Stiffness.

3) The Grand Canyon Skywalk is a horseshoe-shaped glass walkway 4,000 ft above the floor of the canyon (see below).



Which of the following probably describes the material used for the support structure. Explain.

a) The material for the support beams is probably expensive, high-strength, high-carbon steel.
b) The material for the support beams shown is probably inexpensive, low-strength, low-carbon steel.

B, The skywalk support beams are designed to minimize deflection, which is a much more rigorous requirement than simply designing for strength. Since most alloys of a given base metal have essentially the same modulus of elasticity, there is no advantage in using a stronger and more expensive alloy when designing to minimize deflections.

4) The strongest creatures on the planet are insects (if one considers strength to weight). For example, the rhinoceros beetle can lift up to 850 times its own weight. What design feature do most insects have in common that contributes to their strength?

The rhinoceros beetle:

Arthropods like insects, arachnids, and crustaceans have a stiff exoskeleton which contributes to their strength by increasing the area moment of inertia of their limbs. Because of this, the strength to weight ratio of their bodies is higher and better able to withstand torsion and bending. Note that this would not be an advantage against direct shear. Also note that the exoskeleton is probably not the biggest contributor to their incredible strength versus size. The primary contributor to this is because the strength of a

limb is a function of area, whereas weight of a limb is a function of volume. Therefore, if you were shrunken down to the size of an insect, your strength to weight ratio would increase simply by virtue of getting smaller (your strength would decrease by a power of 2, and your weight would decrease by a power of 3).

5) A hollow, cylindrical drive shaft has been shown to fail in torsion. To make the shaft more resistant to torsion it would be better to:
   a. Replace the hollow shaft with a solid shaft.
   b. Increase the diameter of the shaft, but maintain the shaft wall thickness

   Explain why. Either answer could be correct depending on the explanation. Replacing it with a hollow shaft of a larger diameter and same wall thickness would increase the resistance to torsion without (possibly) adding as much weight to the vehicle as a solid shaft would. Given two shafts of identical material and outside diameter, a solid shaft certainly will resist torsion more than a hollow shaft, therefore replacing it with a solid one of the same diameter would increase the resistance to torsion and might not require modifications elsewhere in the drive train.