Materials and Mechanics in Medicine | HS2019

Solutions to Exercise 1: Biomaterials I

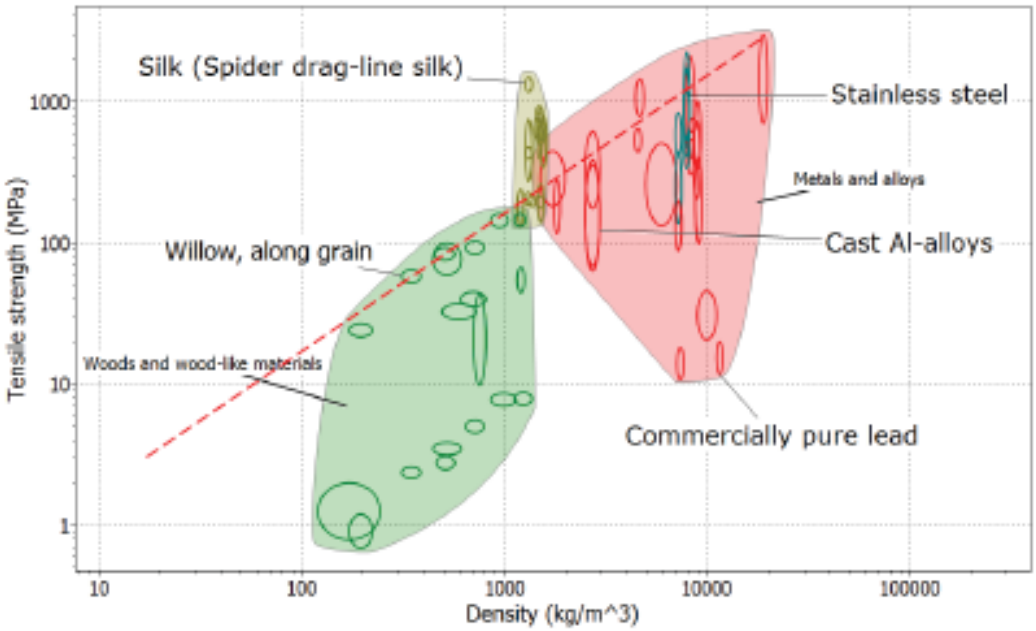
1. List two advantages and disadvantages of the three classes of materials discussed in class. How could a composite material overcome some of the disadvantages?

Material	Advantages	Disadvantages
Metals	Strong, Tough, Ductile, can be formed into complex shapes, Inert	Corrosion, stress shielding, wear debris, metal ion allergies
Ceramics	Biocompatible, low wear, microbial resistance, strong in compression, no corrosion	Expensive, difficult to machine and shape, brittle, prone to sudden catastrophic failure
Polymers	Easily formed into complex structure, degradability, flexibility, tunable properties,	Possible toxic degradation products, Properties change with sterilization, deform over time, Weaker properties than metals and ceramics

A composite can have been properties which reflect both components. For instance, a polymer can be made stronger in tension by adding fibers, or made more friendly to bone growth by adding hydroxyapatite ceramics.

2. You are looking for a material to design a wire for use in the body which is strong in tension, light and biocompatible. Using the material selection diagrams below, what design criteria can you use? Which synthetic or natural material would be good based on these criteria?

One good criterion to optimize for this application would be strength/density. One sees in the below curve that the ratio for steel and willow is not that different. The natural fibers, like spider silk and composites, are strong, light and biocompatible.



3. The following implant material was tested in uniaxial tension and the following data was obtained:

Strain (%)	Stress (MPa)
0	0
0.06	50
0.1	90
0.16	145
0.2	180
0.3	230
0.4	260
0.5	295
0.6	310
0.7	320
0.8	330

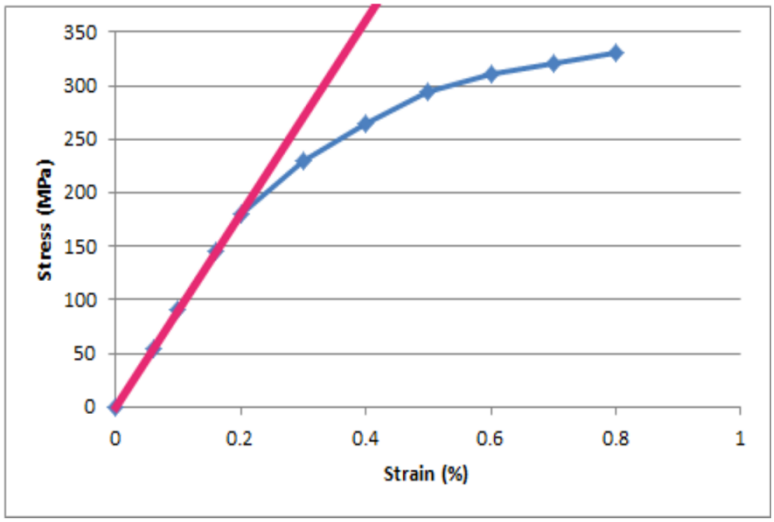
Plot the stress/strain curve and estimate the elastic (Young's) modulus, yield strength, failure strength.

We get a curve with the following estimates:

Young's modulus = 145/0.0016 = 90 GPa

Yield strength = 175 MPa

Failure strength = 330 MPa



What kind of material is this? If this material was cold worked, how would the stress/strain curve change?

This is definitely a metal due to its ductility and strength (probably stainless steel). Cold working will increase the yield strength and failure strength, and the material will be less ductile.

Explain on a microstructural level how this change comes about?

Cold working will increase the dislocation density which stiffens the material and makes it less ductile because dislocations get tangled and their progression through the material is hindered.

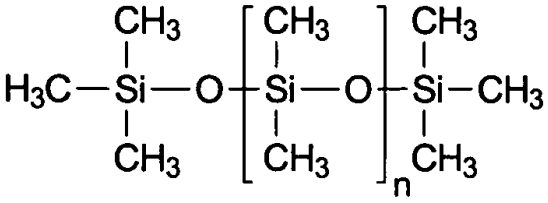
4. What polymer is found below?

a. Silicone oxide

b. Poly diimethyl silicone oxide

c. Poly dimethylsiloxane

d. Poly vinyl chloride



5. What is the molecular weight of polyethylene used in implants?

a. 300 Da

b. 300 kDa

c. 300 mDa

d. 3 MDa