

BMEN E3010 Biomaterials Module - Prof. Lu

Homework #1: Assigned on 11/17, Due on 12/1 before 10am (Gradescope submission).

(Use lecture slides as well as assigned readings (Ratner, Callister, and Black) to answer these questions), 135 points

1. **(30 points)** Please review *section II. 1, 2, 3.2, 3.5* of the *Biomaterials Science* text by Ratner et al. Using your own words, answer the following questions *as concisely as possible*.
 - a. What is the purpose and sequence of inflammation? Be concise!
 - b. What are fibrous capsules and how may they contribute to atrophy around an implant?
 - c. Why are implants often hosts for infection?
 - d. What are cytokines and what are some of their most prominent activities?
 - e. What is the purpose of blood coagulation, and how may this be injurious in the context of blood-materials interactions?
2. **(25 points)** Assume that a metal with a BCC structure has atom contact along the body diagonal.
 - a. Derive the relationship between the axial length (a) and the radius of the metal ion (R)
 - b. Show that the atomic packing factor of a BCC metal is 0.68
 - c. Calculate the density for Chromium, a BCC metal with an *ionic* radius of 0.063 nm.
3. **(25 points)** Stainless steel is one of the most common type of material used in the body.
 - a. What is the elemental composition of AISI 316L?
 - b. Explain the function of the major alloying elements: Cr, Ni and Mo
 - c. Calculate the %cold work (%change in area) of a stainless steel rod with an initial diameter of 0.07 m and a length of 0.18 m. The final diameter of the rod was 0.05 m and the cold worked length was 0.30 m.
 - d. What other treatment is needed after cold work to relieve internal stresses?
4. **(30 points)** The following tensile testing data was obtained for an unknown specimen:
 - a. Plot the stress-strain curve, and clearly label the elastic and plastic deformation regions.
 - b. Determine the modulus of elasticity, yield strength, ultimate tensile strength, fracture strength, and ductility (be careful with units)
 - c. From your answers to parts a and b, decide whether this sample is likely based on a metal, ceramic or polymer. Justify your choice.
5. **(25 points)** Compare and contrast the following biomaterials in terms of 1) composition, 2) mechanical properties (E , yield strength, ductility, fracture toughness) and 3) biocompatibility. To do this, make a comparison table and be concise.
 - A. Ti-6Al-4V
 - B. Hydroxyapatite
 - C. Ultra high molecular weight polyethylene (UHMWPE)

Stress (MPa)	Strain (%)
98	0.06
150	0.10
260	0.17
300	0.20
450	0.30
600	0.40
680	0.50
780	0.60
840	0.70
850	0.80
855	0.90
710	1.00
Failure	