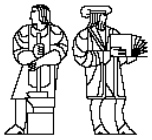

16.423J/HST515J Space Biomedical Engineering and Life Support
Extreme Environment & Bone Homework Assignment #1

Extreme Environments:
(4 points) Describe two themes that most interested you in the reading/lectures on living in extreme environments. Why? Keep answers to 1/2 page for each theme.

Bone:
(6 points total) The goal of this aspect of the assignment is to further investigate the changes that age and environmental loading (1G, microgravity, etc.) have on geometry and bone mineral density of tubular bone. You are to perform simulations using a computer spreadsheet or Matlab.

Long bones can be simulated as hollow tubes, which are subjected in life mainly to bending stresses, Generally, the moment arms do not change with age although load magnitudes do change.

Starting conditions for young adult femur shafts.

Female outer radius, r_o = 1.47cm Male outer radius, r_o = 1.67 cm
Female inner radius, r_i = 0.97 cm Male inner radius, r_i = 1.16 cm

Assume that remodeling normally increases inner radius at the rate of 0.004 cm/year (from measured data in males). The geometry of a hollow tube with effective mineral density of solid bone ρ_m = 1.05 gm/cm^3.

$$I = \frac{\pi}{4}\left(r_o^4 - r_i^4\right)$$

$$Z = \frac{I}{r_o}$$

where I is cross-sectional Moment of Inertia and Z is Section Modulus

$$A = \pi\left(r_o^2 - r_i^2\right)$$

$$BMD = \frac{A\rho_m}{2r_o}$$

Problems to Solve:
1. (3 points) Find the section modulus of young adult femoral shafts. Assume that this is maintained through life (assuming constant skeletal loading). A) Derive an expression

for r_o as a function of changing r_i (this is messy). B) Show how the section modulus can be maintained through age 85. C) What happens to the BMD?

2. (1 point) What happens to BMD (and other parameters) if remodeling rates (increase in r_i) double? (assume constant Z).

3. (2 points) Assume that loading is reduced by 30% at age 60, remaining constant thereafter. Assume a linear effect on Z. What happens to BMD and other parameters?