1. Harry *"The HULC"* Henderson, a 23 year old, 67kg gymnast performs a one-armed handstand as shown in Figure 1A. This stunt obviously creates a stressful situation for the upper extremity joints, which are not accustomed to bearing the weight of the body. This stunt also involves impact, which increases the load by a factor of 3.5. The critical location for Harry is the neck of his radius shown in Figure 1B. At the elbow, the radius shares the load with the ulna, withstanding approximately 40% of the load through the elbow joint (Markholf et al., J Bone Joint Surg, 1998). Note that the radial head is eccentric relative to the neck of the radius, so that the applied load is offset from the midline of the critical area – the radial neck.

   (a) Calculate the tensile stress in the cortical bone, if the radial neck outer diameter is 3.7cm and the cortical bone thickness is 2.3mm. Determine if Harry will suffer a fracture of the radial neck using the yield stress as the failure criterion and assuming bone properties are the same in tension and compression.

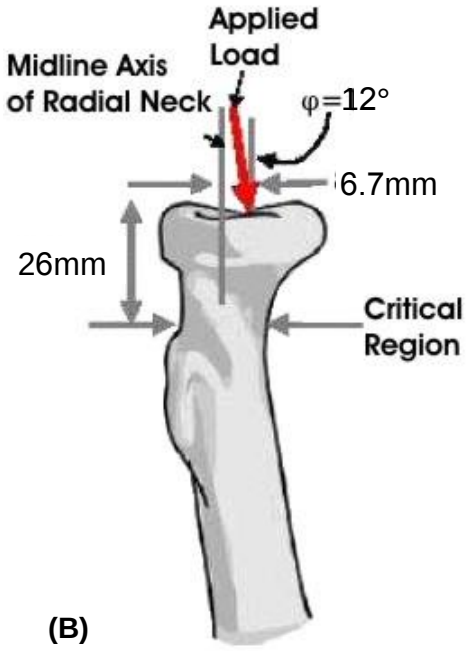

Figure 1. (A) Harry performing a one-armed handstand. (B) Close-up of Harry's proximal radius.

   (b) Harry is now 75 years old (and weighs = 75 kg) and to prove his gymnastics abilities to his grandchildren, decides to try the same trick. The radial neck outer diameter has shrunk to 2.5cm and his bone thickness is now 1.2 mm. Determine if he will suffer a fracture now.

   (c) For an undisclosed amount of bonus points: explain why they call him "The HULC"
   HINT: Early in his career he identified that he may have *upper extremity* problems later in life and decided to dedicate his efforts to a group of experts in this area.
   HINT: Depending on what you found in part (b), Harry may have to have some interaction with these experts just down the road at the corner of Richmond and Cheapside…

2. You are a Masters student studying femoral diaphyseal fractures. Because you couldn't get any volunteers and you need to get your research done, you subject yourself to planar radiographs to calculate your hip joint reaction forces and to determine the dimensions of your cortex. You can then assess your risk of fracture using the criteria that the maximum strength of cortical bone is 120MPa in tension and 210MPa in compression.

   (a) Calculate your fracture risk (assume an age of 25 and a weight of 67kg) with a cranial-caudal (superior-inferior) joint force acting on the femoral head, parallel to the long axis of the femur, of 3.5 times body weight. Assume the load is the only hip joint reaction force and it acts 9cm from the mid axis of your femur. You measured the outer diameter of you femur to be 37mm, with a cortical thickness of 8mm. You may assume a circular cross-section and material properties as given above. What is your risk of suffering a fracture?

   (b) After a long week in the lab having x-rays taken of your hip you decide to go to Boler Mountain to let off some steam. You get a little overconfident and decide to show off to your lab mates by jumping off a mound of snow left by an errant groomer. This results in significant airtime and you land rather hard resulting in an **anterior-posterior** (not vertical as in part a) force of 5.5 times body weight at 6.2cm from the femoral axis. Do you fracture your femur upon landing?Assume that the critical location of stresses in the femur is at the mid-shaft location, 45cm distal to the hip joint center. (Use the tensile strength (50MPa) as the failure criteria.)

3. Write a 1-page synopsis on bone remodeling and Wolff's law. Explain how remodeling occurs, and give an example of bone adaptation due to exercising, lack of exercise, and space flight. Please cite your literature sources.