Explore Engineering 2011 Biomedical Engineering YESS Program
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Introduction
The Explore Engineering program at the University of Connecticut gives a group of high school juniors a chance to learn about several different branches of engineering. In the Biomedical Engineering branch, we focus on the testing, modeling, and simulation of the mechanical responses of biological materials. The 2011 BMX group consisted of:

Group #1: Kevin, Matt, Matt Group #2: Andrew, Shira, Kahlyn
Group #3: Calin, Jake, Sam Group #4: Hannah, Gabby, Kristina
Group #5: Megan, Ben, Steph Group #6: Mitch, Jaime, Dhanya

Aortic Root Inflation Experiment
In this experiment, a set of nonlinear stress and strain data were extracted using a vessel inflation test. In a vessel inflation test, pressure is applied to one end of a blood vessel while the other end is sealed off. In this particular experiment, the vessel was the aortic root, which is the artery that connects the aortic valve at the outlet of the heart to the aortic arch. The root is also important because it is the origin point of the two coronary arteries. The end of the root was naturally sealed against the applied pressure by the shutting of the aortic valve. Stress and strain were calculated by:

\[
\varepsilon = \frac{D - D_0}{D_0} \quad \sigma = \frac{P}{t} \quad G = \frac{B - B_0}{B_0} \quad E = \frac{\Delta \sigma}{\Delta \varepsilon}
\]

Abaqus was again used to generate a simulation of the aortic root inflation experiment. Here, a more sophisticated non-linear material property set was used to model the tissue’s mechanical response to loading. To save time, the aortic root itself was modeled as a cylinder. The results generated by Group #5, can be seen below:

Stent Migration Testing
Stents are used extensively to treat the repair of cardiovascular disease. In this study, each group examined a unique self-expanding stent. The radial strength of the stent was recorded for several baseline deployment conditions, and then for a sheep (ovine) heart at the aortic valve. The students recorded migration forces in the sheep of 1132-3289 N, with a higher resistance observed in the ventricular direction. The baseline data can be seen below.

Uniaxial Tension Testing and Simulation
Uniaxial tension was used to determine the Young’s Modulus of several materials. Since uniaxial tension testing is most effective when performed on homogeneous materials, steel and aluminum were used. Young’s Modulus is the slope of the line created by stress-strain coordinate pairs. The uniaxial test was performed by clamping a long, thin specimen of a material at either end and pulling it apart until failure. A Tinius-Olsen uniaxial tension machine was used in this experiment.

Residual Stress Ring Testing
Presence of residual stress in arteries was noted in the 1980s. Residual stress is likely due to the differential growth and remodeling of arteries during body development. One of the important consequences of residual stress is that it appears to homogenize the transmural distribution of stresses within the arterial wall.

The amount of residual stress present in porcine arteries was measured using a simple ring test. Circular cross sections of the vessel were cut and allowed to move freely. The presence of residual stress forced the tissue to spring apart to a recorded opening angle (θ).

Center of Gravity Experiment
A reaction board was used to determine the center of gravity (CoG) of one student in each group. An average CoG of 50.8% for male students and 47.9% for female students was calculated. Shown at right is Group #1 performing the center of gravity experiment.

Simulation of Lower Back Loading During Lifting
A simulation-based study of lower back loading comparing bending at the back and with bending at the knees (results of the bending at the back simulation by Group #3 can be seen to the right).