GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

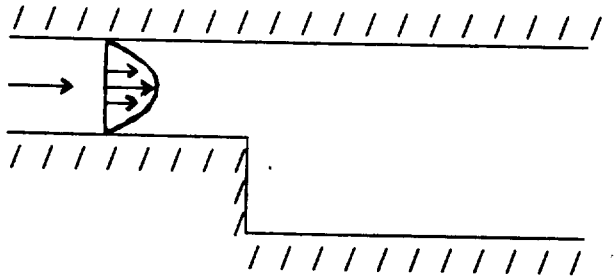
Ph.D. Qualifiers Exam - Spring Quarter 1995

BIOENGINEERING
EXAM AREA

Assigned Number (**DO NOT SIGN YOUR NAME**)

-- Please sign your name on the back of this page --

1. To study the influence of flow separation on the biology of cultured endothelial cells, a parallel-plate flow chamber is modified so as to incorporate a backward facing step in the one surface as illustrated below.



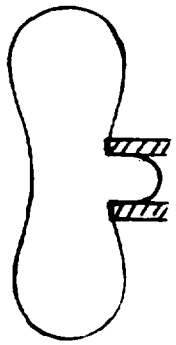
a. Describe and draw the flow pattern in this parallel plate flow chamber, focusing on the separated flow region and providing as much detail as possible.

b. Discuss the relevance of this to blood flow in large arteries under physiologic conditions.

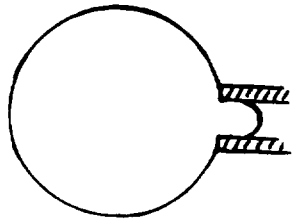
c. Experiments are to be carried out in which the expression of cell adhesion molecules will be investigated. In the design of this flow chamber, what are limiting factors which must be taken into account?

2. Micropipette technique has been used extensively to measure the mechanical properties of individual cells, e.g., the shear elastic modulus of the red blood cell membrane. To evaluate the mechanical property coefficients, mechanical analysis is required to solve the boundary value problem of the cell deformation under the aspiration pressure applied by the micropipette, as discussed in the Cell Biomechanics course.

In an experiment designed to study the effect of osmolarity on the shear elastic modulus of the red cell membrane, the red cells are suspended in a hypotonic solution. As a result, they are swelled into a nearly spherical shape from their natural bi-concave shape, which yields an uniform and isotropic tension on the cell membrane prior to the micropipette aspiration. Discuss the key differences between the mechanical analysis for these pre-swelled cells and that for the bi-concave cells, including differences in the underlying assumptions and governing equations.



Micropipette aspiration of a red cell originally in its natural b-concave shape



Micropipette aspiration of a red cell that has been pre-swelled into a nearly spherical shape

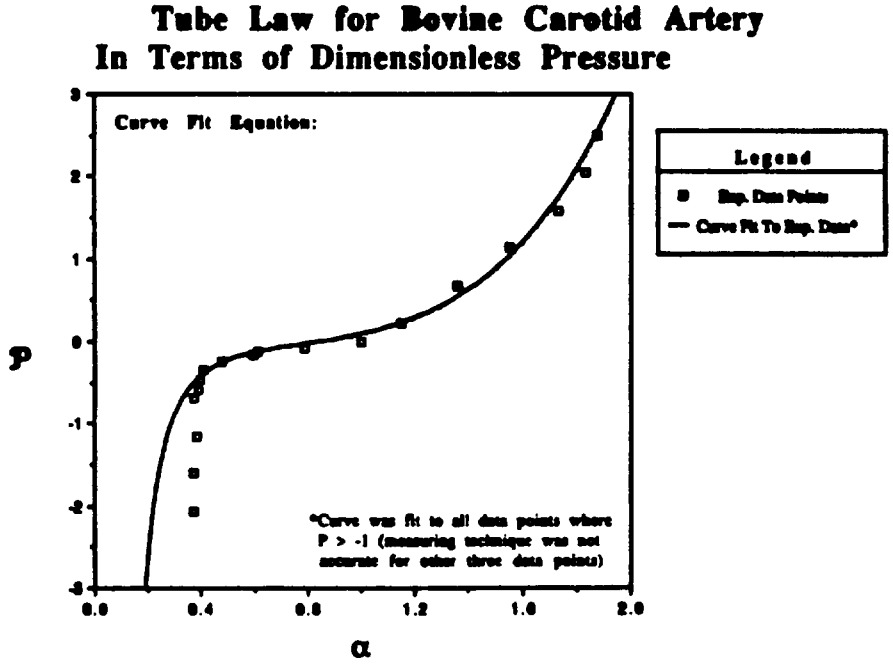
3. Mechanical studies of arteries under pressure yield a curve of non-linear elasticity.

(a) Draw this curve of stress versus strain carefully defining each of the variables.

(b) Explain this curve in terms of the microstructure of the arterial wall.

(c) What is the physiologic significance of the concept of elastic strain energy density for arteries under normal arterial conditions?

(d) Over the entire range of stresses from tension to compression, the pressure area relationship is called the "tube law" shown in the figure below. Explain the shape of this curve in terms of the mechanics of the wall.



(e) Describe three physiologic situations where the full range of the tube law would be important.