M.E. Ph.D. Qualifier Exam
Fall Semester 2000

GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Semester 2000

Bioengineering
EXAM AREA

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

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

Problem III

The following are discussion questions. Please answer them clearly and succinctly illustrating what you write with an appropriate sketch wherever possible.

(a) The constitutive equation governing soft tissues is, to a first approximation, quasilinear viscoelastic.

(i) What is the definition of a quasilinear viscoelastic solid?

(ii) Given your definition, describe how you would experimentally determine if it is appropriate for describing the mechanical behavior of a particular tissue?

(iii) How would you experimentally determine the functional relationships that follow from assuming quasilinear viscoelasticity?

(b) The arterial wall is generally subjected to external tethering and pressure and shear forces exerted by the flowing blood.

(i) Discuss the stresses in the wall induced by each of these forces and their relative sizes. Include numerical approximations, if possible.

(ii) Estimate the hoop stress in a human aorta under physiologic conditions.

(iii) Sketch the distribution of hoop stress through the thickness of the arterial wall neglecting pre-stress and assuming both thin walled (thickness much smaller than radius) and thick walled behavior.

(iv) How does your answer to c) change in the presence of residual strain? Illustrate your answer with appropriate sketches.

Problem IV

A. Identify the primary attributes of atherosclerosis leading to heart attacks.

B. The fluid mechanic behavior of blood through the cardiovascular system of an adult may have features such as pulsatility, non-Newtonian behavior and turbulence. Contrast flow through a femoral artery with flow through the pulmonary venules. Provide estimates of the vessel diameter and flow rates through these vessels.

C. Calculate an estimate of the Reynolds number for these vessels.

D. Describe the type of flow expected through these vessels in terms of as pulsatility, non-Newtonian behavior and turbulence. Would you expect these aspects to be important or not for these two vessel?

E. Provide an example of a situation where turbulence would be expected. What is the physical mechanism causing this turbulence?

F. What types of analytical solutions are suitable for describing the flows in the coronary artery?

G. Diseased arteries may suddenly thrombose causing acute ischemia. Assume platelet adhesion is proportional to shear stress and coagulation is inversely proportional to shear stress.

Provide a hypothesis as to the hemodynamic mechanism of acute thrombosis and ischemia in coronary artery disease.