

Seminar

Unsteadiness and Turbulence in Biomedical Flows: Speech and Cardiovascular Examples

Michael W. Plesniak

Mechanical Engineering, Purdue University

3:00 – 4:00 p.m. Friday, April 25, 2008

Huitt-Zollars Pavilion, Embrey Engr. Building

Abstract

A particularly exciting research era has been enabled by the nexus of biology, (cyber)informatics, and nanotechnology. This seminar focuses mainly on one element of this – bio fluid dynamics. Flow in the human body is designed to be laminar. A few exceptions where turbulence plays a role are speech production and pathological flow in the circulatory system. Speech production involves unsteady pulsatile flow and turbulent structures that affect the aeroacoustics. Examples of pathological blood flow in which unsteadiness, separation and turbulence are important include regurgitant heart valves, stenoses or blockages, and arterial branches and bifurcations. Pulsatile unsteady phenomena, coherent vortical structures and transitional flow or turbulence occurring at low Reynolds numbers are common to these biological flows. An overarching motivation for studying hemodynamics and speech production is to facilitate surgical planning, i.e. to enable physicians to assess the outcomes of surgical procedures by using faithful computer simulations. Such simulations are on the horizon with the advent of increasingly more powerful high performance computing and cyberinfrastructure, but they still lack many of the appropriate physical models. The goal of our cardiovascular research program is to investigate the flow-induced stimuli of pathological flows on the endothelial cells lining the intima of the arteries. The motivation is to understand the cycle of plaque formation that occurs in the disease atherosclerosis. A multidisciplinary effort with colleagues in Biomedical Engineering enabled study of fluid dynamics in the presence of live cells. Because actual cells are subjected to the flow and then analyzed for biochemical and genetic response, the model cannot be scaled-up. Thus, techniques such as micro-PIV and MEMS-based wall shear stress sensors are required to characterize the flow. Another important objective is to enable computations with realistic inlet and boundary conditions. Our work on perturbations addresses the sensitivity of pulsatile flow in arteries to changes in inlet conditions such as curvature and velocity profile distortion. The phonation research has many facets and does lend itself to scaled-up *in vitro* models of the vocal tract. We have found that the unsteady “Coanda effect” is an important viscous flow phenomenon that is relevant to phonation.

Biographical Sketch

Dr. Michael W. Plesniak is Professor of Mechanical Engineering at Purdue University, and former *Eugene Kleiner Professor for Innovation in Mechanical Engineering* at Polytechnic University in Brooklyn, NY. He served as the Director of the Fluid Dynamics & Hydraulics program at the National Science Foundation from 2002-2006. Prof. Plesniak earned his Ph.D. degree from Stanford University, and his M.S. and B.S degrees from the Illinois Institute of Technology; all in Mechanical Engineering. Dr. Plesniak was elected a *Fellow of ASME* in 2006. He has served as an Associate Editor for the ASME *Journal of Fluids Engineering*. His research interests include: bio fluid mechanics, turbulence transport and mixing enhancement, cavitation, three-dimensional boundary layers, gas turbine cooling, energy and sustainability, environmentally-benign consumer aerosol sprays, and entrainment control. Dr. Plesniak has authored one hundred refereed archival publications and conference papers, over fifty non-refereed publications and presentations, and has presented numerous invited seminars and keynote addresses.