

DEPARTMENT OF MATHEMATICS

VIGRE Funding Report

(due 30 days after semester of support)

Semester/Summer and Year:

Fall 2008

Name: Rebecca Vandiver

List the graduate courses you have taken this semester (including independent studies), your grades, and the instructors:

Course	Title	Grade	Instructor
MATH920	Dissertation	S	Goriely

List the title, date and location of any talks you have given, either here or elsewhere:

"Growth and Remodeling," Guest talk in the Biomechanical Engineering course, Department of Aerospace and Mechanical Engineering, University of Arizona, November 2008.

"Schizogenous Aerenchyma Formation, Stem Hollowing, Elastic Cavitation and Differential Growth in Plants and Elastic Tissues" (poster), IUTAM Symposium on Cellular, Molecular and Tissue Mechanics, Woods Hole, Massachusetts, June 2008.

If you are working on your dissertation, include a one paragraph description of your research progress. If you have not yet begun dissertation research, describe your progress toward finding a dissertation topic and advisor and beginning that research.

I have continued to study the development of residual stress induced by differential growth of biological cylindrical structures and study its possible mechanical role in modifying material properties. Specifically, during the fall semester I studied the effect of differential growth and residual stress on the overall mechanical response of the cylindrical structure within the framework of morpho-elasticity through an analysis of the buckling properties of residually stressed cylindrical tubes. This method allows me to understand the role of growth and anisotropic response in the buckling of arteries.

List publications, if any.

Vandiver, R., Goriely, A. Tissue tension and growth in cylindrical elastic structures. Submitted for a theme issue in Philosophical Transactions of the Royal Society A, 2008.

Vandiver, R., Goriely, A. Tissue tension and axial differential growth of cylindrical structures in plants and elastic tissues. Accepted for publication in Europhysics Letters, 2008.

Vandiver, R., Goriely, A. Morpho-elasto-dynamics: the long-time dynamics of elastic growth. Accepted for publication in Journal of Biological Dynamics, 2008.

Check all activities you completed during the funded period:

Academics:

- Independent Study
- Oral Comprehensive Exam
- Commence Thesis Research
- Conference attendance
- Conference participation
- Complete PhD

Professional development and outreach:

- AP Calculus Visit
- High School Workshops
- Undergraduate Research Project
- Undergraduate Research Seminar
- Super TA
- Mentoring junior graduate students for the qualifying exams
- RTG (help organize)
- Research Seminar (help organize)

Other (please specify)

I wrote a considerable amount in my dissertation. For my vertical outreach component I presented multiple lectures in the large lecture class Math Analysis for Engineers and taught various modules on the wave equation, heat equation, and Fourier transforms.

Attach a brief statment about your academic progress and professional development during the period of support.

VIGRE Graduate Fellowship Report
Fall 2008
Rebecca Vandiver

This past fall I was fortunate to receive a VIGRE Fellowship which allowed me to progress further in my research. I have continued to study the development of residual stress induced by differential growth of biological cylindrical structures and study its possible mechanical role in modifying material properties. This past semester my advisor and I submitted a paper titled, "Tissue tension and axial differential growth of cylindrical structures in plants and elastic tissues," and it was accepted for publication in Europhysics Letters. In this letter we study the role of tissue tension on the overall rigidity and stability of the cylinder. A detailed analysis, based on nonlinear elasticity, of the effect of tissue tension on the mechanical properties of growing cylinders reveals a subtle interplay between geometry, growth, and nonlinear elastic responses that help us understand some of the remarkable properties of stems and other biological tissues.

We also submitted a paper titled, "Tissue tension and growth in cylindrical elastic structures," for a theme issue in the Philosophical Transactions of the Royal Society A. In this paper the effect of differential growth and residual stress on the overall mechanical response of the cylindrical structure is studied within the framework of morpho-elasticity through an analysis of the buckling properties of residually stressed cylindrical tubes. This method is applied to cylinders made of isotropic materials, as well as anisotropic materials. Tissues such as blood vessels exhibit anisotropic behavior due to the fiber orientations which tend to have preferred directions. We use the multi-layer model for arteries introduced by Holzapfel, et al. (2004) which includes layer-specific histological features. It is a structural model in the sense that it incorporates information about the orientations of the collagen fibers in each layer. We show that the coupling between growth and anisotropic response greatly enhances the overall flexural rigidity of the structure.

I spent the majority of the semester working on my dissertation in order to defend in the spring semester. However, I was able to participate in a small outreach project tied to the Math Analysis for Engineers course. To complete my educational training, I presented multiple lectures in the large lecture class and taught various modules on the wave equation, heat equation, and Fourier transforms.