26th Annual James F. Bell Memorial Lecture in Continuum Mechanics
Department of Mechanical Engineering, Johns Hopkins University

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Tuesday, October 13, 2020
3:00 PM via Zoom https://wse.zoom.us/j/98427352821 | Passcode 781551

"Soft Material Characterization by Magnetic Resonance Phase Field Imaging"

Presented by Professor Ellen M. Arruda

Tim Manganello/BorgWarner Department Chair of Mechanical Engineering and the
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The characterization of the mechanical properties of soft materials, including elastomers and the soft tissues of knee and shoulder joints has been a major focus of my laboratory. Obtaining the mechanical properties of soft tissues is particularly challenging for a number of reasons, the first of which is that they are very soft, and direct gripping is fraught with problems. They are also anisotropic, therefore testing in multiple directions and deformation states is typically required. Our interest in developing full-knee computational models necessitates accurate constitutive models of the soft tissues of the knee. Finite element (FE) models of the knee can provide specific information on individual tissue contributions with respect to global joint function, as well as the coupling and coordination among tissues during macroscopic joint motions. Computational models offer precise, full-field, and complete descriptions of deformation manifesting from normal motions, injury causing activities, injured and diseased joints, and reconstructive procedures. FE models further have the potential to conduct clinically meaningful, individualized joint analyses.

In this talk I will show how geometric effects, heterogeneous deformation, and experimental uncertainty have manifested as subject-to-subject variability in the mechanical response of the anterior cruciate ligament (ACL). I will describe our use of full-field methods to overcome these challenges and the tremendous opportunity they afford in characterization of the non-linear, anisotropic mechanical properties of soft tissues. Specifically, we have pioneered a new experimental method for finite strain characterization of soft materials using the phase field signal during in-situ mechanically deforming materials with magnetic resonance imaging. We have validated our approach using a well-characterized elastomer and recently applied the approach to the bundles of the ACL and the patellar tendon of the knee. We add to our approach to virtual fields method of characterization. Time permitting I will also describe our very recent efforts to also characterize materials without assuming a constitutive model a priori.

Professor Ellen M. Arruda is the Tim Manganello/BorgWarner Department Chair of Mechanical Engineering, and the Maria Comninou Collegiate Professor of Mechanical Engineering at the University of Michigan. She also holds courtesy appointments in Biomedical Engineering and in Macromolecular Science and Engineering. Professor Arruda earned her BS degree in Engineering Science (with Honors) and her MS degree in Engineering Mechanics from Penn State, and her PhD degree in Mechanical Engineering from MIT. Professor Arruda teaches and conducts research in the areas of theoretical and experimental mechanics of macromolecular materials, including polymers, elastomers, composites, soft tissues and proteins, and in tissue engineering of soft tissues and tissue interfaces. Her recent honors and awards include the 2019 Nadai medal from the American Society of Mechanical Engineers, the 2018 Rice medal from the Society of Engineering Science, the 2015 Outstanding Engineering Alumnus Award from the Pennsylvania State University, the 2014 Distinguished Faculty Achievement Award from the University of Michigan, the Ann Arbor Spark Best of Boot Camp award 2012, and the 2012 Excellence in Research Award by the American Orthopaedic Society for Sports Medicine. Professor Arruda has more than 100 papers in scientific journals. She also holds thirteen patents. Her H-index is 35 (ISI). Professor Arruda is a Fellow of the American Society of Mechanical Engineers, the American Academy of Mechanics, and the Society of Engineering Science. She is currently President of the American Academy of Mechanics. She is a member of the National Academy of Engineering (class of 2017).