Arezoo Hajesfandiari
Contact: ah62@buffalo.edu, Tel: (716) 445-2582

Education:

Ph.D., Mechanical Engineering, 2015

University at Buffalo, State University of New York
Dissertation: Size-dependent fluid mechanics: theory and application
Advisor: Dr. Gary Dargush

M.S., Mechanical Engineering, 2011

University at Buffalo, State University of New York
Thesis: Influence of density-weighted vorticity on linear stability characteristics of shear layers

B.S., Mechanical Engineering, 2007

University of Tehran, Tehran, Iran

Research Interests:

Theoretical and Computational Solid and Fluid Mechanics, Size-dependent Continuum Mechancs, Micro/Nano Mechanics, MEMS/NEMS Devices, Biomechanics, Multiphysics phenomena, Finite Element Analysis, Computational Fluid Mechanics, Boundary Element Method

Teaching Experience:

Department of Mechanical and Aerospace Engineering, University at Buffalo

Teaching Assistant

Undergraduate courses: Fluid Mechanics, Heat Transfer, Dynamics, Machines and Mechanisms

Co-Instructor

Undergraduate courses: Fluid Mechanics, Dynamics
Graduate courses: Engineering Analysis, Fluid Mechanics, Heat Transfar

Publications (archival journals):

1. **Hajesfandiari A.**, Hadjesfandiari A.R., and Dargush G.F. Boundary element formulation for plane problems in size-dependent thermoelasticity, *Eng. Anal. Bound. Elem.*, **82** 210-226, 2017.
2. **Hajesfandiari A.**, Hadjesfandiari A.R., and Dargush G.F. Boundary element formulation for plane problems in size-dependent piezoelectricity, *Int. J. Numer. Meth. Engrg.*, **108**(7), 667-694, 2016.
3. **Hajesfandiari A.**, Dargush G.F., and Hadjesfandiari A.R. Size-dependent fluid dynamics with application to lid-driven cavity flow, *J. Non-Newton. Fluid Mech.*, **223**, 98-115, 2015.
4. Hadjesfandiari A.R., **Hajesfandiari A.**, and Dargush G.F. Skew-symmetric couple-stress fluid mechanics, *Acta Mechanica*, **226**(3), 871-895, 2015.
5. **Hajesfandiari A.** and Forliti D.J. On the influence of internal density variations on the linear stability characteristics of planar shear layers, *Phys. Fluids*, **26**(5), 054102, 2014.
6. Hadjesfandiari A.R., Dargush G.F., and **Hajesfandiari A.** Consistent skew-symmetric couple stress theory for size-dependent creeping flow, *J. Non-Newton. Fluid Mech.*, **196**, 83-94, 2013.

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Publications (online):

1. Hadjesfandiari A.R., **Hajesfandiari A.**, and Dargush G.F. Pure plate bending in couple stress theories, https://arxiv.org/ftp/arxiv/papers/1606/1606.02954.pdf (2016).
2. Hadjesfandiari A.R., **Hajesfandiari A.**, and Dargush G.F. Integral representation for 3D steady size-dependent thermoelasticity, https://arxiv.org/ftp/arxiv/papers/1704/1704.02318.pdf (2017).

Publications (under review):

1. **Hajesfandiari A.**, Dargush G.F., and Hadjesfandiari, A.R. Rayleigh-Bénard convection flow with couple-stresses, *J. Non-Newton. Fluid Mech*, final review.
2. Hadjesfandiari A.R., Furlani E., **Hajesfandiari A.**, and Dargush G.F. On the size-effects in vibrating silicon crystal micro-beams, *J. Phys. D*, under review.

Publications (in progres):

1. **Hadjesfandiari A**, Sukhotskiy V., Khan M.F., Thundat T., and Furlani E.P. Analytical modeling of microfluidic cantilever sensor with evaporating ethanol, in preparation.
2. **Hajesfandiari A.**, Hadjesfandiari A.R., and Dargush G.F. Size-dependent Timoshenko beam model for microtubules, in preparation.
3. **Hajesfandiari A**., Hadjesfandiari A.R., and Dargush, G.F. Boundary element method for steady state size-dependent creeping flow, *Eng. Anal. Bound. Elem.* in preparation.
4. Hadjesfandiari A. R. and **Hajesfandiari A**. Investigation of size-dependency in free vibration of microbeams based on consistent couple stress theory, in preparation.

Conference Presentations:

1. **Hajesfandiari A**., Hadjesfandiari A.R., and Dargush G.F. Boundary element analysis of thermoelastic effects in size-dependent mechanics, *ASME, International Mechanical Engineering Congress and Exposition*, IMECE2015-53765, Nov. 2015.
2. ***Hajesfandiari A.**, Dargush G.F., and Hadjesfandiari A.R. Size-dependent couple stress fluid mechanics: the influence of boundary conditions, 67th Annual DFD Meeting of the American Physical Society, San Francisco, CA, Nov. 2014.
3. Dargush G.F., Hadjesfandiari A.R., and **Hajesfandiari A**. Steady and unsteady size-dependent couple stress creeping Flow, 67th Annual DFD Meeting of the American Physical Society, San Francisco, CA, Nov. 2014.
4. ***Hajesfandiari A**., Dargush G.F., and Hadjesfandiari A.R. Size-dependent Rayleigh-Benard problem, 66th Annual DFD Meeting of the American Physical Society, Pittsburgh, PA, Nov. 2013.
5. Hadjesfandiari A.R., **Hajesfandiari A**., and Dargush G.F. Size-dependent fluid mechanics, 66th Annual DFD Meeting of the American Physical Society, Pittsburgh, PA, Nov. 2013.
6. ***Hajesfandiari A**., Dargush G.F., and Hadjesfandiari A.R. Size-dependent couple-stress fluid mechanics and application to the lid-driven cavity flow, 65th Annual DFD Meeting of the American Physical Society, San Diego, CA, Nov. 2012.

* Presenting author

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Research Projects:

Finite Element Analysis of Small Size Structural Elements

In addition to the analytical solution, finite element formulations were used to investigate the size-dependent static and dynamic behavior of small scale structures with applications in bioengineering and micromechanics. Based on published data from a series of physical experiments, the bending response of microtubules, some protein filaments in living cell structures, are found to be strongly size-dependent. Using analytical solutions for deformation of a fully clamped cantilever beam, we studied the mechanical properties of microtubules of differing lengths. By assuming isotropic behavior for the microtubules, we estimated the bulk Young's modulus and the length scale parameter required within this theory. We have also studied the vibration of ultrathin silicon cantilever micro-beams and estimated the couple stress length scale parameter of single crystal silicon, based on measured data for the resonant frequency.

Boundary Element Analysis of Size-Dependent Multiphysics

The objective of this research was to explore the effects of size effects in coupled physical problems. In particular, we were interested in the behavior of the materials under electrical and thermal effects. Knowing the fact that the classical theories cannot explain any piezoelectrical or size-dependent thermal response from isotropic materials, we investigated these responses within the framework of the newly developed consistent couple stress theory. For both size-dependent multiphysics problems discussed, we developed the boundary integral representation and numerical implementation. Then, we applied the new BEM formulation to several basic problems in an effort to validate the robustness of the numerical implementation and to examine size-dependent response. The results suggest that flexoelectric and thermoelastic size effects could become important in a broad range of small scale components and devices subjected to electrical and thermal loadings. They also offer exciting new opportunities for nanotechnology by observing size-dependent piezoelectric or flexoelectric behavior in isotropic and other centrosymmetric dielectric materials and the importance of thermal flexion in non-centrosymmetric materials (unlike the classical theory).

Development of Size-dependent Fluid Mechanics Theory

I have been involved in the development of a consistent size-dependent couple stress theory for fluids, which we believe may represent an important step in advancing fluid mechanics for flows with small-scale characteristics. In this theory, we define the force-stress and couple-stress tensors and formulate the equations of motion. Based on purely kinematical considerations, we suggest the mean curvature rate tensor as the corresponding compatible measure of deformation. Next, by using the energy rate equation, we demonstrate that in a continuum theory of couple-stress materials, body-couples cannot be distinguished from an equivalent body-force and surface force-traction system. More importantly, based on resolving properly the boundary conditions, we show that the couple-stress tensor is skew-symmetric and, thus, completely determinate. This also confirms the mean curvature rate tensor as the fundamental deformation rate measure, energetically conjugate to the couple-stress tensor.

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Research Projects (continued):

Numerical Analysis of Size-dependent Fluid Flows

In order to explore consequences of the fully determinate couple stress theory, we concentrated on steady creeping flow and used the Boundary Element Method to solve two-dimensional problems. The boundary integral equations were written in terms of velocities, angular velocities, force-tractions and couple-tractions as primary variables. Boundary element method was applied for the solution of two basic problems in the framework of size-dependent couple stress fluid mechanics.

We also examined the effects of couple-stresses in lid-driven cavity and Rayleigh-Bénard convection problems by developing a stream function-vorticity CFD formulation. The focus was on the potential effect of size-dependency on the stability of both problems. For the lid-driven cavity problem, the investigation covered a range of Reynolds numbers and includes an evaluation of the critical state beyond which a stationary response was no longer possible. In the case of the Rayleigh-Bénard convection, the onset of convective instabilities and the flow characteristics for different combinations of size-dependent parameter, Prandtl number and Rayleigh number were investigated. The additional boundary conditions associated with couple stress theory were found to be important in determining the flow pattern and critical flow characteristics in both problems.

Employment History:

Research Scientist, 2015-present

Department of Mechanical and Aerospace Engineering, University at Buffalo

Teaching and Graduate Assistant, 2008-2014

Department of Mechanical and Aerospace Engineering, University at Buffalo

Design Engineer, 2007-2008

Oil and Gas Industry, Tehran, Iran

Professional Memberships:

Society of Women Engineers (SWE)
American Physical Society (APS)