BRADLEY DARRALL

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EDUCATION

University at Buffalo, State University of New York
Ph.D., Mechanical Engineering, June 2016
M.S., Mechanical Engineering, June 2015
B.S., Mechanical Engineering, June 2011

PROFESSIONAL EXPERIENCE

Teaching Assistant Professor (2016-)
Instructor (2014-2016)
Teaching Assistant (2013-2016)
NSF Research Fellow (2011-2016)
Research Consultant at Sprung-brett RDI (2012)
Undergraduate Assistant (2010-2011)

RESEARCH SUMMARY

Work has been done developing numerical methods for size-dependent mechanics based on the new consistent theories of couple-stress elasticity by Hadjesfandiari and Dargush and size-dependent piezoelectricity by Hadjesfandiari. Novel contributions include the development of variational formulations and mixed finite element formulations for continuum analysis of both couple-stress elasticity and size-dependent piezoelectricity. A finite element formulation for couple-stress incompressible Stokes' flow was also developed, and recently work is being done to extend this formulation to higher Reynolds number flows. It was shown that including both displacement and rotation as fundamental variables in these formulations, and then introducing Lagrange multipliers to enforce compatibility, has major advantages over other formulations. Simulations were carried out using the corresponding finite element codes that offer excellent insights into the theory and can be used as benchmark results for other researchers in the field. More recently, finite element formulations corresponding to size-dependent thermoelasticity have been developed. Work is currently being done to extend all of these size-dependent finite element formulations to 3D analysis, analysis of non-isoptropic materials, and also to incorporate a couple-stress contact mechanics algorithm into the current FE software. The formulations themselves have the potential to aid in the simulation and development of technology on micro- and nano-length scales.

Perhaps the greatest issue that size-dependent mechanics theories face at the current juncture is the lack of experiments being performed with the aim of measuring couple-stress related material parameters. Currently, experiments are being worked on with the aim of approximating the couple-stress parameters for water by studying the size-dependency of flow through micro-needles and the drag force acting on micro-spheres.

Mixed Convolved Action (MCA), a recently developed theory by Dargush, involves fractional calculus and convolutions to define an action that is capable of recovering all governing differential equations, as well as initial conditions, and boundary conditions of the dynamical system at hand. Importantly, MCA has the capability of modelling dissipative systems with a single scalar functional, as opposed to introducing an additional dissipation function. Codes are being developed based on these new novel variational formulations applicable to a very broad range of dynamical problems. Extensive work has been done in developing MCA based algorithms for analysis of elastodynamics, dynamic viscoelasticity, heat diffusion, dynamic thermoelasticity and dynamic poroelasticity in both 2- and 3-dimensions.

Most recently, for the first time, a true variational principle has been developed for time-dependent quantum mechanics based on least convolved action. This type of formulation has immense potential in the field of quantum mechanics. Dating back to the beginnings of QM, physicists such as Dirac and Schrodinger recognized the importance of a least action principle for the time-dependent Schrodinger equation, however these formulations were never realized until much later when Feynman introduced his famous path integral formulations, which have certainly had profound effects. The current formulations are however significantly different than Feynmans, and are potentially much more attractive. Based on these new least convolved action principles, 2- and 3-d finite element in space and time methods have been formulated, and will be used to tackle many interesting problems going forward.

TEACHING SUMMARY

Over the past several years I have made great strides in developing as a teacher. In Spring of 2014 I was afforded the unique opportunity to be part of an educational experiment in collaboration with the office of undergraduate education at UB. I served as one of the primary instructors for Dynamics (EAS208) for three semesters beginning in Spring of 2014. In these two years I helped to develop and implement two distinct lecture styles, which we referred to as “passive” and “active” lectures. The idea was to closely compare these two styles both qualitatively and quantitatively in hopes to optimize the way that a class is run in order to achieve the best student experience.

More recently, as of summer 2016, I have been serving as faculty at The University at Buffalo as a Teaching Assistant Professor. I have had the pleasure of creating curriculum for, and teaching, many courses already, including Fluids and Thermal Lab (MAE338), Structural Analysis (MAE315), Matlab/Linear Algebra (EAS230), Intermediate Dynamics (MAE345), and of course Dynamics (EAS208).

INSTRUCTOR

Dynamics (EAS208)
Spring 2014, 2 sections, enrollment: 130
Fall 2014, 1 section, enrollment: 65
Spring 2015, 2 sections, enrollment: 130
Spring 2017, 2 sections, enrollment: 130
Spring 2018, 1 section, enrollment: 100

Matlab/Linear Algebra (EAS230)
Summer 2016, 1 sections, enrollment: 40

Fluids and Thermal Lab (MAE338)
Winter 2016, 1 section, enrollment: 10
Fall 2016, 10 sections, enrollment: 250
Summer 2017, 1 sections, enrollment: 10
Fall 2017, 8 sections, enrollment: 200
Summer 2018, 1 section, enrollment: 20

Structural Analysis (MAE315)
Fall 2016, 1 section, enrollment: 60
Fall 2017, 1 section, enrollment: 65

Intermediate Dynamics (MAE345)
Spring 2017, 1 section, enrollment: 75
Spring 2018, 2 sections, enrollment: 135

TEACHING ASSISTANT

Dynamics (EAS208)
Spring 2016, 4 sections, enrollment: 220

Fluids and Thermal Lab (MAE338)
Fall 2015, 7 sections, enrollment: 200

Statics (EAS207)
Spring 2013, 3 sections, enrollment: 150

UNDERGRADUATE ASSISTANT

Applied Mathematics for Mechanical and Aerospace Engineers (MAE376)
Summer 2011

Dynamics (EAS208)
Spring 2010, Fall 2011, Spring 2012

PRIMARY SCHOOL GUEST TEACHER

Provided tours of the UB fluids and thermal lab and taught fluids experiments for students of Westminster school (K-8) during their annual field trip to UB.
Winter 2016

Travelled to Westminster elementary to teach engineering classes.
Spring 2016

ADVISEMENT and ADDITIONAL ACADEMIC ROLES

UNDERGRADUATE RESEARCH ADVISEMENT

Student: Jingye Tan
Project: *FEA of couple-stress fluids* (Spring/Summer 2018)

Student: Seth Messer
Project: *Design of 2D conduction experiment: comparing infrared thermal maps to FEA* (Summer 2018)

Student: Cale Byczkowski
Project: *Design of scalable fluid mechanics experiments to test size-dependent effects* (Summer 2018)

Student: Paul Leoniak
Project: *Couple-stress contact mechanics finite element algorithm* (Summer 2017)

Student: William Abt
Project: *Acoustic analysis and design of composite drum shells using FEM* (Summer 2016)

Student: Lim Yi Ang
Project: *Experimental analysis of size-dependent flow through micro-needles* (Spring 2016)

UNDERGRADUATE LAB UPGRADES COMMITTEE

This committee assesses the state of our undergraduate educational laboratories and implements annual improvements. I am currently in the process of assessing the fluids and thermal lab for improvements during the current lab upgrade cycle.

MAE UNDERGRADUATE MENTOR

Beginning in Fall 2016 I have continuously served as one of the departments undergraduate mentors. I regularly meet one on one with individual students and advise them on everything from research, to industry opportunities, to managing life as an undergraduate student.

EAS UNDERGRADUATE MENTOR

As of Spring 2017 I have served as one of the many undergraduate mentors for the School of Engineering and Applied Sciences. This role is connected with the freshman EAS202 seminar course. I am assigned a roster of students that I meet with both as a group and individually throughout the year. I advise these students on what to expect continuing forward in engineering school and answer any questions they may have.

UNDERGRADUATE STUDENT EXCELLENCE AND DIVERSITY COMMITTEE

Beginning in Fall 2016 I have served on our departments "Student Excellence" committee, aimed at promoting and recognizing academic excellence and diversity amongst out undergrads.

AWARDS

Tau Beta Pi Buffalo "Professor of the Year" (2017)
National Science Foundation Graduate Research Fellowship (2011-2015)
SUNY Chancellor's Award Nominee (2016)
UB Presidential Fellowship (2011-2015)
Senior Scholar Award (2011)
Zimmer Undergraduate Research Scholarship (2010)
UB Provost Scholarship (2007-2011)
Buffalo Engineering Society Scholarship (2007-2011)
NYS Regents Scholarship (2007-2011)

PUBLICATIONS

Many publications are available as pdfs at buffalo.edu/~bdarrall/

Darrall, B.T., Dargush, G.F. "Three-dimensional finite element formulation for size-dependent couple stress elasticity", in preparation.

Darrall, B.T., Tan, J., Dargush, G.F. "2D Finite element method for size-dependent fluid mechanics", in preparation.

Darrall, B.T., Dargush, G.F. "Mixed convolved action principle for the time-dependent Schrodinger's equation and corresponding time-space finite element method", in preparation.

Darrall, B.T., Dargush, G.F. "A least convolved action principle for quantum mechanics", in preparation.

Pedgaonkar, A., Darrall, B.T., Dargush, G.F., “Mixed displacement and couple stress finite element method for anisotropic centrosymmetric materials”, *Acta Mech.,* in submission.

Darrall, B.T., Hadjesfandiari, A.R., Dargush, G.F. “Finite element method for size-dependent thermoelastic analysis”, *Lat. Am. J. Solids Struct.,* in submission.

Darrall, B.T., Dargush, G.F. “Variational principle and time-space finite element method for dynamic thermoelasticity based on mixed convolved action”. *Eur. J. Mech. A-Solids,* **71**, 351-364 (2018).

Darrall, B.T. “Variational principles and time-space finite element methods based on mixed convolved action for heat diffusion, dynamic thermoelasticity, poroelasticity, and time-dependent quantum mechanics”, *Ph. D. Dissertation*, University at Buffalo, The State University of New York (2016).

Darrall, B.T., Dargush, G.F. “Mixed convolved action variational methods for poroelasticity”, *ASME J. App. Mech,* **83**, 091011 (2016).

Dargush, G.F., Apostolakis, G., Darrall, B.T., Kim, J. “Mixed convolved action variational principles in heat diffusion”, *Int. J. Heat & Mass Transfer,* **100**, 790-799 (2016).

Darrall, B.T., Dargush, G.F. “Mixed convolved action principles for dynamics of linear poroelastic conitinua”, ASME, IMECE2015-53163, Houston, TX, November 2015.

Dargush, G.F., Darrall, B.T., Kim, J., Apostolakis, G. “Mixed convolved action principles in linear continuum dynamics”, *Acta Mech.*, **226**, 4111-4137 (2015).

Darrall, B.T. “Variational and 2D finite element formulations for size-dependent elasticity and piezoelectricity”, *M.S. Thesis*, University at Buffalo, The State University of New York (2015).

Darrall, B.T., Hadjesfandiari, A.R., Dargush, G.F. “Size-dependent piezoelectricity: A 2D finite element formulation for electric field-mean curvature coupling in dielectrics”, *Eur. J. Mech. A-Solids*, **49**, 308-320 (2015).

Darrall, B.T., Dargush, G.F., Hadjesfandiari, A.R. “Finite element Lagrange multiplier formulation for size-dependent skew-symmetric couple-stress planar elasticity”, *Acta Mech.*, **225**, 195-212 (2014).

GRADUATE COURSEWORK

CIE511: Advanced Solid Mechanics
CIE617: Advanced Finite Element Analysis
CE620: High Performance Computing
MAE507: Engineering Analysis 1
MAE508: Engineering Analysis 2
MAE515: Advanced Fluid Mechanics 1
MAE529: Finite Element Methods for Structures and Solids
MAE540: Computational Fluid Mechanics
MAE562: Analytical Dynamics
MAE570: Thermodynamics of Materials
PHY507: Quantum Mechanics 1
PHY555: General Relativity

SOFTWARE and PROGRAMMING

Programming: Matlab, Fortran, Maple, HTML, c++, MPI, OpenMP
CAD/Graphics: AutoCAD, Pro Engineer, Adobe Photoshop, Adobe Illustrator
Finite Element: Abaqus, ANSYS
Other: Microsoft Office Suite