Anthony Hester

Education

PhD	Mathematics	University of Alabama in Huntsville	2007
MS	Mathematics	University of Alabama in Huntsville	2005
MS	Physics	Georgia Institute of Technology	1994
BS	Math, Physics Computer Science Minor	University of Alabama	1992

Teaching

- **2021 Spring.** Teaching MA 452, Introduction to Real Analysis. Conducting seminar on algebraic topology, with an emphasis on free abelian groups and their application to homology theory.
- **2020 Fall.** Taught MA 442, Algebraic structures. Conducted a seminar on algebraic topology with an emphasis on cell complexes, CW complexes, and simplicial complexes.
- **2020 Summer.** Conducted seminar on image processing using a Raspberry Pi.
- **2020 Spring.** Taught MA 452, Introduction to Real Analysis. Conducted a seminar on continuum mechanics with an emphasis on flows, the continuity equation, and Vlasov's equation.
- **2019 Fall.** Taught MA 490/690 on abstract ordinary differential equations, Lie theory, and symmetry groups in differential equations. Conducted a seminar on the application of differential geometry to rigid body motion. Advised a undergraduate student on their physics senior thesis, and had them program a 6 degree of freedom model of a quad copter.
- **2019 Summer.** Conducted a seminar on Lie theory and symmetry groups in differential equations using Olver's book *Applications of Lie Groups to Differential Equations.*
- **2019 Spring.** Taught differential geometry MA490/590 in which we rigorously defined a manifold with boundary, tangent spaces, cotangent spaces, integration on manifolds, Lie algebras, and other related concepts. Proved the generalized Stoke's theorem and connected it to all the results from vector calculus. Through the lectures and the homework, had the students connect the theory to what they have learned in previous math and physics classes. Developed my own notes for the class, assimilating the concepts from the existing books, and adding my own ideas which I have not found in existing literature. In particular, I extended the definition of the Fréchet derivative and the Gateaux derivative to functions of arbitrary domains, not necessarily open. In my notes, I reproved all the standard results concerning the Fréchet derivative, which allowed me to redefine tangent curves, hence, tangent spaces, on the boundary of a manifold. With this redefinition, I reproduced all the results for Fréchet differentiable functions between manifolds with boundary without having to posit the existence of said function beyond the definition of the manifold. This extension allowed me to quickly and completely rigorously present all the theory concerning differentiable manifolds to the students. It also allowed me to assign computational problems using manifolds with boundaries to the students, since all the tools we developed in class to perform said computations do not require providing extensions to functions beyond the manifold! Also, conductied a seminar in convex analysis where I have the students present selected results from Barbu and Precupanu' book *Convexity and Optimization in Banach Spaces.*
- **2018 Fall.** Conducted a seminar in differential geometry. Used Fubini's theorem to demonstrate the relationship between alternating tensors and the size of a parallelepiped, then connected this result to the measure of a manifold, id est, arc length, surface area, et cetera. Conducted an in depth analysis of the Fréchet derivative which included proving the injective function theorem, the open mapping theorem, the inverse function theorem, the implicit function theorem, and other related results.
- **2018 Summer.** Conducted an in depth seminar in tensor analysis. We began by reviewing some basic group theory, and using this theory to prove fundamental properties of permutations. We then examined covariant, contravariant, and mixed tensors, showing that arbitrary products of rank 1 tensors form a basis for the vectors space of tensors of a particular type. We defined alternating tensors and the wedge product, proved a result about forming a basis for spaces of alternating tensors using the wedge products of rank 1 alternating tensors, and then proved various properties of alternating tensors.

- **2018 Spring.** Conducted a seminar in complex analysis, using Rudin's book *Real and Complex Analysis* as a guide. We first examined the topological concepts of connectedness and path connectedness, proving that an open subset of the complex plane is connected if and only if it is path connected. We next showed that if we consider the complex plane as a vector space over itself, then the complex derivate equals the matrix representation of the Fréchet derivative in the standard basis. We proved that all analytic functions are infinitely differentiable and representable by taking derivatives of their power series. We proved the a function is analytic if and only if it is holomorphic (the complex derivative exists). We also proved results concerning path integration in the complex plane, including a result that replaced the Lebesgue measure with an arbitrary complex measure.
- **2017 Fall.** Continued the seminar on signed and complex measures. We used the Jordan decomposition to define the integral on a signed and a complex measure. We then went on to prove the Radon-Nikodym theorem, and explore some of its consequences.
- **2017 Summer.** Conducted a seminar on signed and complex measures. We demonstrated the existence of the Hahn decompositions of signed measure spaces, and the almost everywhere agreement of such decompositions. Using the Hahn decomposition, we proved the existence of the Jordan decomposition of a signed measure.
- **2017 Spring.** Taught undergraduate real analysis (MA452). Conducted a seminar in harmonic analysis, focusing on the Fourier transform. In particular, we defined the Fourier transform on L^2, proved it was an isometry, demonstrated its translation invariance, and showed other important properties. We also examined the connection between Fourier series and the Fourier transform.
- **2016 Fall.** Conducted an advanced undergraduate seminar with two points of focus. First, had the returning members of the seminar communicate the fundamentals of measure theory to the new members of the seminar. Second, examined the application of measures to electromagnetic theory. In particular, looked at the idea of representing charge with signed measures, and the implications of this representation to the electromagnetic model.
- **2016 Spring/Summer.** Conducting an advanced undergraduate seminar on differential geometry. Looking at how to define a measure on a manifold, using pre-measures and Carathéodory's theorem, that agrees with intuitive notions of length and area on curves and surfaces. Proved that the Fréchet definition of size on manifolds agrees with the measures we defined.
- **2015 Fall.** Conducted an advanced undergraduate seminar on measure theory. In particular, the seminar covered the Banach-Tarski paradox, how measure theory obviates the issues raised by the paradox, how to build the Lebesgue measure, and proving that the Lebesgue σ-algebra contains the Borel σ-algebra of $\mathbb{R}^n$. We discussed how compactness allows the construction of a pre-measure on left open, right closed boxes in $\mathbb{R}^n$, and proved Carathéodory's theorem, thereby extending the pre-measure to the Lebesgue measure on $\mathbb{R}^n$.
- **2015 Summer.** Conducted an advanced undergraduate seminar on the mathematical tools used in differential geometry. In particular, the students studied the Fréchet derivative, its relation to the Gâteaux derivative, the inverse function theorem, and the implicit function theorem. One student, Juan Guzman, created Latex notes on these topics and presented his notes to the group.
- **2015 Spring.** Conducted an advanced undergraduate seminar on the mathematical foundations of classical electrodynamic theory.
- **2015 Fall.** Conducted a graduate level seminar on evolution equation in Banach space, which included a detailed presentation of the Hille-Yosida theorem and the Lumer-Phillips theorem.
- **2014 Summer.** Conducted a seminar on machine learning using kernels for an undergraduate student, John Shrontz. I had John create a paper explicating the mathematical theory behind kernel induced feature spaces, which included proving Mercer's theorem.
- **2014 Spring** Conducted a graduate level seminar on evolution equation in Banach spaces with an emphasis on vector-valued function calculus and semigroup theory.
- **2013 Summer.** Conducted a seminar on support vector machines for an undergraduate student, John Shrontz. I had John create a paper explicating the mathematical theory behind support vector

machines, and some of the algorithms for computing them. I then had him use the Percepton algorithm (in MATLAB) to train the computer to automatically classify hand written digits. He presented his results at an undergraduate conference.

- **2013 Spring.** Conducted a seminar on probability with an emphasis on image processing. In particular, we examined the theoretical justification of Gibb's sampling, and performed computer simulations.
- **2012 Fall.** Led a seminar in image processing theory. In particular, we examined the theory behind Principle Component Analysis, and performed computer simulations.
- **2009 Fall.** Presented a seminar on evolution equations in Banach spaces. Discussed mild solutions as presented by Benilan, Crandall, and Pazy in their manuscript *Nonlinear Evolution Equations in Banach Spaces.*
- **2008 Spring.** Presented a seminar on the calculus of vector-valued functions, covering concepts such as strong and weak measurability, Pettis integration, and strong and weak differentiation.
- **1994 June to 1996 June.** Taught undergraduate Calculus and Linear Algebra at Georgia Tech.
- **1992 September to 1994 June.** Taught freshman lab and senior electronics lab in the Physics department at Georgia Tech.

Research

My Ph. D. dissertation focused on the existence of fixed points for pseudo-contractive mappings. To arrive at these results, I relied heavily on theory concerning time evolution in Banach spaces. Though a discipline unto itself, fixed point theory had its genesis in PDE theory. This connection motivated me to learn more about the application of fixed point theory to other areas of mathematics like PDE's and semigroups, as well as, areas outside of mathematics such as quantum modeling, information theory, machine learning, and control theory. I am currently researching the connection between semigroups and information extraction, the application of classical fixed point theory to random fixed point theory, and the impact of fixed point theory on control theory.

- **Paper.** "Fixed point approximation under Mann iteration beyond Ishikawa," with Claudio Morales. *Commentationes Mathematicae Universitatis Carolinae*, 61,3 (2020) 265-275.
- **NSF Grant.** "Exploring a New Approach to Learning Mathematics," submitted with Claudio Morales. Aimed at collecting performance data on using **problem based learning**, a type of collaborative learning that connects theory and application, to teach students mathematical concepts. Not awarded.
- **Talk.** 2015-Mar, AMS Regional Conference at UAH. "Fixed Points of Random Operators."
- **Paper.** "Semigroups Generated by Pseudo-Contractive Mappings under the Nagumo Condition," with Claudio Morales. *Journal of Differential Equations*, 245 (2008), 994-1013.
- **Talk.** 2008-Oct, AMS Regional Conference at UAH. "Semigroups Generated by Pseudo-Contractive Mappings under the Nagumo Condition."
- **Dissertation** 2007-Dec, "Semigroups Generated by Pseudo-Contractive Mappings under the Nagumo Condition."
- **Thesis** 2005-Dec, "The Pettis Integral with Applications to Ordinary Differential Equations and Fixed Point Theory."

Work

Dr. Hester is the Chief Mathematician for Quantum Information Extraction, Incorporated in Huntsville Alabama, where he concentrates on the development of new technologies in the areas of optics, sensing, communication, and machine learning for DoD and commercial applications. Dr. Hester has 20 years of experience in analysis and development of simulations and models for missile defense and signal processing. He has extensive experience in developing engagement simulations for missile defense systems, high fidelity 6DOF simulations, object tracking with Kalman filters, and developing guidance and control algorithms for missiles. He also developed algorithms for image compression, pattern recognition, information extraction, compressive sensing, and other image processing techniques.

- **June 2013: QIE.** Dr. Hester has applied current advances in compressive sensing to create algorithms for manifold learning. Dr. Hester was also involved in designing an advanced SLM for use in optical computers and image and signal processing applications.
- **July 2001, Davidson Technologies Inc.** Dr. Hester has created high fidelity 6DOF simulations of missile flight. Dr. Hester has also been involved in GNC algorithm development, and object tracking algorithm development. He has helped design and code sliding mode based controllers and autopilots for exo and endo atmospheric interceptors. He has been engaged in the modeling and simulation of ballistic missile defense systems. He was involved in analyzing engagement timelines for boost-phase and mid-course interceptors, and in conducting many-on-many engagement analysis for regional defense far-term architectures. Dr. Hester was engaged in the modeling and simulation of ballistic missile defense systems. He has also developed tools for evaluating radar architectures and radar tracking algorithms.
- **June 1996, OPTS, Inc.** Dr. Hester performed analyses of data compression and pattern recognition techniques. He used various Fourier techniques for compressing data and recognizing patterns within data. He developed software, in C++, that implemented data compression and pattern recognition algorithms. He also designed and built hardware to implement data compression and pattern recognition algorithms in digital signal processors (DSP's). Dr. Hester conducted an extensive study of charge-coupled devices, including designing and building electronics to drive the CCD. Other work involved: designing high-speed/high-current clock drivers; programming programmable logic devices (PLD's), specifically Altera MAX 7000 and FLEX 10K devices; programming TI C44 DSP; programming Analog Devices 21160 DSP; and designing analog-to-digital converter (ADC) and digital-to-analog converter (DAC) circuitry.
- **June 1994, Georgia Tech Mathematics Department, Teaching Assistant.** Dr. Hester taught undergraduate mathematics courses, including calculus and linear algebra.
- **September 1992, Georgia Tech Physics Department, Teaching Assistant.** Dr. Hester taught undergraduate physics labs at Georgia Tech, including advanced electronics.
- **Summer 1991, Teledyne Brown Engineering, Coop Student.** During this work period, Dr. Hester developed software code in FORTRAN language, for simulating neural networks.
- **Spring 1991, University of Alabama, Tuscaloosa, Research Assistant.** Dr. Hester worked as a research assistant for Dr. Clavelli. He wrote software in Schoonchip (symbolic manipulator) to calculate the decay probabilities of various subatomic particles.
- **Summer 1990, Teledyne Brown Engineering, Coop Student.** Dr. Hester programmed, in FORTRAN, software code to calculate the right ascension and declination of the sun at an arbitrary time.
- **Spring 1990, University of Alabama, Tuscaloosa, Research Assistant.** Dr. Hester served as a research assistant for Dr. David Goldberg. He studied the effects of allele cardinality on the convergence rate of genetic algorithms. He programmed, in Pascal, a simulation of genetic algorithms with various allele cardinalities.
- **Summer 1989, Teledyne Brown Engineering, Coop Student.** Dr. Hester programmed, in FORTRAN on a VAX 11/780 computer system, a file management program.
- **Summer 1988, Teledyne Brown Engineering, Coop Student.** Dr. Hester programmed, in FORTRAN language on the VAX 11/780 system, a graphical user interface to a database.
- **Summer 1987, Marshall Space Flight Center, High School Apprentice.** Dr. Hester was employed in the summer high school apprentice research program at NASA. He programmed, in FORTRAN language on a VAX 11/780 system, a simulation of the optical elements in the Solaris satellite using matrix methods as the basis for the simulation.