

Abraham D. Smith, PhD

Experience

AUGUST 2015 — ONGOING

University of Wisconsin-Stout

Assistant Professor

Tenure-track faculty in the Department of Mathematics, Statistics and Computer Science and at UW-Stout, Wisconsin's Polytechnic University. Extending geometric research expertise into effective data analysis. Focusing on individualized student development and mentorship with 24 credit teaching load.

Contact: smithabr@uwstout.edu

AUGUST 2015 — ONGOING

Geometric Data Analytics, Inc.

Senior Mathematician and Scientific Programmer

Developing new geometric and topological methods for machine learning and pattern recognition. Producing commercial-quality software for analyzing big data.

Contact: abraham.smith@geomdata.com

SEPTEMBER 2011 — JULY 2015

Fordham University

Peter M. Curran Visiting Assistant Professor

Performed full-time faculty duties, including 3+2 teaching load, student mentoring, active participation in department committees, curriculum development, and technical infrastructure development. Directing undergraduate research in differential geometry, moving frames, and computational methods. Research students: Kathleen Toth and Meredith Lukas.

AUGUST 2009 — MAY 2011

McGill University

MSRI/NSF Postdoctoral Fellow

Continuing research on the geometry of integrable systems and conservation laws, particularly using the techniques of exterior differential systems. Supported by an NSF All-Institutes Postdoctoral Fellowship administered by the Mathematical Sciences Research Institute through its core grant DMS-0441170. Mentored by Niky Kamran and hosted by the Department of Mathematics and Statistics at McGill University.

Education

MAY 2009

Duke University

Doctor of Philosophy (Mathematics)

Integrability of Second-Order PDEs and the Geometry of $GL(2)$ -Structures

Directed by Robert L. Bryant. In December 2004, received Master of Arts in Mathematics during PhD program.

MAY 2003

University of Wisconsin-Madison

Bachelor of Science

Majors in Mathematics and Physics, with honors in Mathematics.

Participated in NSF VIGRE undergraduate research programs directed by James Propp (2001, 2002) and Dan Knopf (2003).

Research Interests

Topological Data Analysis, Scientific Computing, Integrable Systems, Geometry of PDEs Mathematics Education.

In applied mathematics, I develop fast, stable algorithms for data analysis that rely on topological and geometric methods. In pure mathematics, I am particularly interested in developing local differential geometry (in the sense of Élie Cartan) and in the applications of these techniques to integrability phenomena appearing in physical systems, from theoretical and computational perspectives. My work emphasizes the links between commutative algebra, the structure theory of Lie pseudogroups, and the micro-local geometry of the characteristic variety of PDEs.

Publications and Preprints

- 2018 *Involutive Tableaux, Characteristic Varieties, and Rank-one Varieties in the Geometric Study of PDEs* in **Geometry of Lagrangian Grassmannians and Nonlinear PDEs**, Banach Centre Publications. Preprint available at [arXiv:1701.04930](https://arxiv.org/abs/1701.04930) [math.DG] A monograph in covering a computational, algebraic approach to studying differential equations.
- 2018 *Supervised Learning of Labeled Pointcloud Differences via Cover-Tree Entropy Reduction*. with P. Bendich, J. Harer, and J. Hineman. [arXiv:1702.07959](https://arxiv.org/abs/1702.07959) [cs.LG] A new, fast algorithm for distinguishing multiple samples from an underlying distribution. (Drafts under revision.)
- NOVEMBER 2017 *Geometric Cross-Modal Comparison of Heterogeneous Sensor Data* (Primary Author: C. Tralie.) [arXiv:1711.08569](https://arxiv.org/abs/1711.08569) [cs.CV] Multi-modal modal comparison of aerial data streams. Published in Proceedings of IEEE Aeroconf.
- JULY 2015 *Constructing Involutive Tableaux with Guillemin Normal Form*. (*Symmetry, Integrability, and Geometry: Methods and Applications*. Vol 11, 053) [arXiv:1410.7593](https://arxiv.org/abs/1410.7593) [math.AP]
- OCTOBER 2014 *Degeneracy of the Characteristic Variety*. [arXiv:1410.6947](https://arxiv.org/abs/1410.6947) [math.AP].
- AUGUST 2014 *What is Guillemin normal form?* [[preprint](#)]
- AUGUST 2012–ONGOING *Symbol*, software for working with Exterior Differential Systems in the Sage computer algebra system. Code development at bitbucket.org/curieux/symbol_sage
- OCTOBER 2010 *A Geometry for Second-Order PDEs and their Integrability, Part I*. [arXiv:1010.6010](https://arxiv.org/abs/1010.6010) [math.DG]
- JANUARY 2010 *Integrable $GL(2)$ Geometry and Hydrodynamic Partial Differential Equations* (*Communications in Analysis and Geometry Vol 18 No 4, 2010*) [arXiv:0912.2789](https://arxiv.org/abs/0912.2789) [math.DG]

Conferences Organized

- APRIL 2020 (IN PLANNING) UW–Stout
MAA Sectional
Planning committee for proposed MAA meeting.
- JULY 2013 Dalhousie University
Pseudogroups and their Applications
A special session at the Summer Meeting of the Canadian Mathematical Society. Joint with Francis Valiquette.
- JULY 2011 Centre de Recherches Mathématiques
Moving Frames in Geometry
A week-long workshop at CRM and Université de Montréal, drawing worldwide experts in moving frames. Joint with Francis Valiquette.

Student Projects Mentored

- 2019–ONGOING *A Sentiment Search Engine* A software-development project by undergraduate Evan Vanden Hoeven to use recurrent neural networks and language encoding to build a search engine that detects the public sentiment of the subject being searched.
- SUMMER 2013 *Moment Maps, Moving Frames, and Computer Vision*. A collaborative research project with undergraduate Meredith Lukas studying the application of Fels–Olver moving frames for computer vision. Funded by a Clare Boothe Luce fellowship.

SUMMER 2013 Mentored three advanced math majors, in preparation for their move to graduate school, through a twice-weekly seminar series with lectures and exercises in representation theory of Lie algebras and applications to differential geometry.

SUMMER 2012 *Curve Optimization in Finsler/Randers geometry*. A collaborative research project with undergraduates Kathleen Toth and Meredith Lukas addressing the question "Can computers draw splines in non-Riemannian geometries?" Funded by Clare Boothe Luce fellowships.

Research Talks

- NOVEMBER 2018 UW–Baraboo
NeXT Wisconsin
“Who is the Proof For?” Peer Review in the Classroom
- MAY 2017 U. Minnesota & Institute for Mathematics and its Applications
Data Analysis Seminar
Using Cover-Trees and Friends for Machine Learning with the CDER Algorithm
- FEBRUARY 2017 North Carolina State University
Geometry and Topology Seminar
Understanding Integrability via Characteristic Varieties and their Secants
- OCTOBER 2016 University of St. Thomas
AMS Sectional Meeting
Progress Toward a Moduli Theory of Involutive Differential Equations.
- SEPTEMBER 2016 IMPAN/Banach Centre
Warsaw
Advanced Topics in Exterior Differential Systems. 3.5-hour lecture series.
- DECEMBER 2015 University of Minnesota
Math-Physics Seminar
How to Build Involutive PDEs.
- MAY 2015 University of Wisconsin-Stout
Department Colloquium
Local Geometry and Differential Equations
- MAY 2015 CyberOptics Corporation, Minneapolis, Minnesota
Science and Technology Talk Series
Least Angle Regression in Compressed Sensing
- MAY 2015 City University of New York, Graduate Center
Kolchin Seminar in Differential Algebra
The Variety of Involutive Differential Systems via Guillemin Form [[video](#)]
- MARCH 2015 City University of New York, Bronx Community College
Department Colloquium
Solving PDEs with almost-commuting matrices An overview of the geometric meaning of Guillemin normal form.
- FEBRUARY 2015 San José State University
Department Colloquium
Local Geometry and Differential Equations
- JANUARY 2015 San Antonio, Texas
AMS/MAA Joint Meetings
Degeneracy of the Characteristic Variety and Canonical 1-forms on Involutive PDEs. Part of the special session Geometries Defined by Differential Forms.
- DECEMBER 2014 City University of New York, Graduate Center
Geometric Analysis Seminar
Reducing PDEs with Degenerate Characteristic Variety.

- SEPTEMBER 2014 Fordham University
Analysis Seminar
How to cheat at solving PDEs. Explicit calculations with Guillemin Normal Form allow us to construct involutive PDEs.
- DECEMBER 2013 Fields Institute
Workshop on Exterior Differential Systems and Lie Theory
Towards Generalized Hydrodynamic Integrability via the Characteristic Variety
 A talk for specialists about using the rank-one and characteristic variety to uncover sub-classes of involutive Lie pseudogroups. [[video](#)]
- NOVEMBER 2013 Fordham University
Analysis Seminar
Exterior Differential Systems as Generalizations of Partial Differential Equations A two-lecture series introducing differential ideals, involutivity, and prolongation.
- AUGUST 2013 Colorado State
SIAM Conference on Applied Algebraic Geometry
Analysis of Symbols and Tableaux, with Sage
- JULY 2013 Estes Park, Colorado
New Directions in Exterior Differential Systems
Hydrodynamic Exterior Differential Systems and Applications to Pseudogroup Structures
 A conference in honor of Robert Bryant's 60th birthday.
- JUNE 2013 Dalhousie University
Summer Meeting of the Canadian Mathematical Society
Tableaux of PDE systems and associated Lie pseudogroups. Part of the special session Pseudogroups and their Applications.
- APRIL 2011 University of Arkansas
Conformal Differential Geometry and Representation Theory
Intrinsic Geometry of Second-Order PDEs
 Part of the [Spring Lecture Series](#) focused on work of Mike Eastwood.
- FEBRUARY 2011 Fordham University
Department Seminar
Intrinsic Geometry for Second-Order Partial Differential Equations
- NOVEMBER 2010 Texas A&M University
Geometry and Analysis Seminar
New G-Structures for the Study of Hyperbolic PDEs
- AUGUST 2010 Brno, Czech Republic
Differential Geometry and its Applications
A New Geometric Framework for Hydrodynamic Integrability. Part of the programme session Natural Operations and General Geometric Structures.
- APRIL 2010 Macalester College
AMS Central Sectional Meeting
A [Proposed] Framework for Hydrodynamic Integrability. Part of the special session Geometric Flows, Moving Frames and Integrable Systems.
- SEPTEMBER 2009 Université du Québec à Montréal
CRM Geometry & Topology Seminar
Integrability of 2nd order PDE and the geometry of GL₂-structures

- APRIL 2009 NC State University
AMS Southeastern Sectional Meeting
A classification for 2nd order PDEs with $GL(2, \mathbb{R})$ geometry Part of the special session Geometry of PDE.
- JANUARY 2009 Washington DC
AMS/MAA Joint Meeting
 Panel member for *Beyond T.A. Training: Calculus Curriculum Development by Graduate Teaching Assistants*
- OCTOBER 2008 Duke University
Geometry Forum
Lie algebroids and integrability theorems
- OCTOBER 2007 University of California, Berkeley
Geometry Seminar
 $GL(2, \mathbb{R})$ structures and integrability
- APRIL 2007 Duke University
Geometry Forum
Finsler geometry and the technique of moving frames

Talks for Students

- DECEMBER 2013 Fordham University
Fordham Math Club
The Algebra of Data A talk for undergraduates introducing the algebra of patches, data entropy, and cryptographic hash functions.
- MAY 2013 Fordham University
Fordham Math Club
How to Count A talk for undergraduates introducing the Orbit-Stabilizer Theorem and Burnside's Lemma.
- FEBRUARY 2012 Fordham University
Fordham Math Club
What is d ? A talk for undergraduates introducing the idea of differential forms, the Poincaré Lemma, and its influence on topology.
- NOVEMBER 2007 Duke University
Graduate/Faculty Seminar
DEs to EDS: How to "solve" PDEs without being clever

Teaching Experience

- FALL 2015 — ONGOING University of Wisconsin-Stout
General Courses
 Teaching **all** levels of undergraduate courses, including College Algebra, Calculus I, Linear Algebra, and Differential Equations, Real Analysis, Machine Learning, graduate Scientific Computing, and independent studies. Overall teaching load 24 credits per year.
- FALL 2011 — SPRING 2015 Fordham University
General Courses
 Teaching **all** levels of undergraduate courses, including PreCalculus, Finite Mathematics, Calculus I, Calculus II, Multivariable Calculus, Linear Algebra I, and Linear Algebra II. Overall teaching load 5 courses per year.
 Acting Course Director for PreCalculus.

- SPRING 2015 Fordham University
Programming for Mathematics and Science
 Designing and teaching **new** 2nd-year course on using Python to develop algorithms for real-world scientific data analysis. Co-Teaching with Prof. Papadakis from Computer and Information Sciences.
- FALL 2013 AND 2014 Fordham University
Seminar in Scientific Communications
 Teaching 3rd-year course on both oral and written scientific exposition, technical writing and editing, and beginner-to-advanced use of \LaTeX .
- FALL 2012 Fordham University
Advanced Topics Course: Differential Geometry
 Designed and taught a **new** senior-level course covering the elements of Riemannian Geometry for mathematics and physics majors.
- FALL 2011 McGill University
Mentor
 Helped train McGill PhD candidate Sara Froehlich in exterior differential systems, and served as minor-topic chair on her Preliminary Examination committee.
- FALL 2005—SPRING 2009 Duke University
Calculus Teacher
 Lecturer for a total of five 30-students sections of Math 32 (Calculus II) or Math 32L (Lab Calculus II) over four semesters.
- FALL 2008 Duke University
Course Supervisor
 Course Supervisor for three sections of Math 41L (Lab Calculus II for entering freshmen). Lecturer for one 30-students section. Lab Instructor for two sections. This was the first full run of a course that I helped design.
- SUMMERS 2006 & 2007 Duke University
Pre-Qual Instructor
 One of two instructors for Pre-Qualifier Preparation Program, a week-long intensive linear-algebra and analysis review for incoming graduate students.
- SUMMER 2005 Duke University
TIP Topology Mentor
 Solely developed and taught a 4-week course on the algebraic topology of surfaces as a special program for three extremely bright teenage students in Duke's Talent Identification Program.
- FALL 2004 Duke University
Lab Instructor
 Lab instructor for one 30-student section of Math 32L (Lab Calculus II).
- FALL 2002 & SPRING 2003 University of Wisconsin
Teaching Assistant
 Teaching assistant for two sections each of Math 221 and 222 (Calculus and Analytic Geometry I and II).

Curriculum Development

SPRING 2017

University of Wisconsin-Stout

Machine Learning

Designed a course on machine learning, to support a concentration in data science for Applied Mathematics and Computer Science students.

FALL 2014

Fordham University

Pre-Calculus Course Management

At the request of the Mathematics Department Chair, regularly meeting with all instructors of Pre-Calculus to ensure course quality and consistency during period of increased enrollment.

FALL 2012–ONGOING

Fordham University

Electronic Teaching Resources

Built and maintain Sage Notebook server and MAA WebWork server for projects and homeworks throughout the Mathematics department. Joint with Shaun Ault and Jay Hineman.

SPRING 2012

Fordham University

Pre-Calculus Course Improvement

Re-designed Pre-Calculus course to better match current student population, in consultation with Prof. Maryham Hastings and the Gabelli School of Business. Produced guidelines and suggestions to ease the burden on adjunct teaching faculty and to improve consistency across different sections and teachers.

FALL 2008

Duke University

Electronic Teaching Resource

Under a teaching mini-grant from the Duke Graduate School, developed an on-line repository called “TRAP” for worksheets, quizzes, and tests using MySQL, Python, Django, and Javascript. Joint with Rann Bar-On.

SPRING 2008

Duke University

Curriculum Improvement

Updated labs and teaching materials for experimental course, Math 41L.

SPRING 2007

Duke University

Calculus Curriculum Review

Helped organize and participated in a graduate student review of the calculus curriculum. The main result was a completely new course, Math 41L, for which we designed a complete syllabus, including textbook selection, homework lists, and lab creation. Full report: www.curieux.us/abe/proposal.pdf

Professional Service

2010–ONGOING **Referee and Reviewer**

Referee for journals such as *Selecta Mathematica*, *Journal of Differential Geometry*, *SIGMA*, *Communications in Analysis and Geometry*, and *Foundations of Computational Mathematics*. Reviewer for the AMS Mathematical Reviews.

2012–2015 **Designer and Administrator of Research Computing Cluster**

Designed and maintain a Linux environment for high-performance scientific computation, used by researchers in many departments across the university. The first project of its kind at Fordham, this project was administratively complex: its construction took collaboration with the computing staff, planning discussions the faculty technology committee, and funding approval from the academic deans.

2011–2015 **Undergraduate Curriculum Committee**

Active member of Fordham Mathematics Undergraduate Curriculum Committee.

2012–2014 **Pi Mu Epsilon Advisor**

Advisor for Fordham’s chapter of the Pi Mu Epsilon mathematical honor society chapter.

2007 Committee Secretary

Secretary of the Duke Graduate Calculus Curriculum Review Committee, which performed a complete review of the first- and second-year curriculum, redesigned syllabi, selected textbooks, and added new courses.

2006 Seminar Organizer

Duke Graduate Student Geometry Seminar.

2005 Association President

President of Duke Math Graduate Student Association during sensitive compensation, placement, and curriculum disputes with the University.

Computer and Technology Skills

Languages: Deep knowledge of L^AT_EX, Sage, Python, MAPLE, Javascript, and SQL. Familiarity with many others.
Can read and interpret any programming language.
Thorough UNIX/Linux system and network administration experience since 1995.
IPv6 certification level "sage" from Hurricane Electric.

Professional Membership

American Association for the Advancement of Science [AAAS].
American Mathematical Society [AMS].
Mathematical Association of America [MAA].
Society for Industrial and Applied Mathematics [SIAM].



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April 4, 2019