CURRICULUM VITAE

Name	**Tevian DRAY**
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EDUCATION

February 1976	**B.S.** in Mathematics, **M**assachusetts **I**nstitute of **T**echnology, Cambridge, MA, USA
December 1977	**M.A.** in Mathematics, University of California, **Berkeley**, CA, USA
December 1981	**Ph.D.** in Mathematics, University of California, **Berkeley**, CA, USA

PROFESSIONAL RECORD

1/88 – present	Department of Mathematics, Oregon State University, Corvallis, OR, USA. *Assistant Professor 1/88 – 8/90; Associate Professor 9/90 – 8/97; Professor 9/97 – present*
2/10 – 4/10	School of Natural Sciences, Institute for Advanced Study, Princeton, NJ, USA. *Visitor*
9/09 – 10/09	Department of Physics, Utah State University, Logan, UT, USA. *Visiting Professor of Physics*
8/02 – 12/02	Grinnell College, Grinnell, IA, USA. *Robert N. Noyce '49 Visiting Professor in the Physical Sciences, Math, and Computer Science*
9/01 – 6/02	Department of Mathematics and Statistics, Mount Holyoke College, South Hadley, MA, USA. *Hutchcroft Visiting Professor of Mathematics*
2/95 – 8/95	Department of Physics and Mathematical Physics, University of Adelaide, Adelaide, AUSTRALIA. *Fulbright Senior Scholar*
8/94 – 1/95	School of Physics and Chemistry, Lancaster University, Lancaster, ENGLAND. *Visiting Research Fellow*
1/91 – 6/91	Mathematical Sciences Research Institute (MSRI), Berkeley, CA, USA. *Senior Member*
10/87 – 12/87	Theoretical Astrophysics Group, Tata Institute of Fundamental Research (TIFR), Bombay, INDIA. *Visiting Professor*
7/87 – 9/87	Institute of Mathematical Sciences, Madras, INDIA. *Visiting Scientist*
1/86 – 6/87	Department of Mathematics, University of York, York, ENGLAND. *Postdoctoral Research Fellow*
1/84 – 9/84 & 4/85 – 12/85	Instituut voor Theoretische Fysica, Rijksuniversiteit Utrecht, Utrecht, THE NETHERLANDS. *Wetenschappelijk Medewerker*
9/84 – 4/85	School of Mathematics, Institute for Advanced Study, Princeton, NJ, USA. *Member*

HONORS & AWARDS

1999	Named a "**Top Prof**" by the Mortar Board Senior Honor Society, OSU.
2004	**Frederick Horne Award** for Sustained Excellence in Teaching Science, College of Science, OSU.
2006	**Renie Award** for best deposit of 2006, National Curve Bank.
2009	**UHC Outstanding Professor**, University Honors College, OSU.
2010	**Fellow**, American Physical Society.
2011	**Loyd Carter Award** for Outstanding and Inspirational Undergraduate Teaching, College of Science, OSU.
2012	**UHC Eminent Professor**, University Honors College, OSU.
2014	**Distinguished Teaching Award** for Distinguished College or University Teaching of Mathematics, Pacific Northwest Section of the Mathematical Association of America.
2014	**Elizabeth P. Ritchie Distinguished Professor Award**, OSU.
2015	**Professor of the Term**, Panhellenic Executive Council of OSU.
2016	**Outstanding Educator in Higher Education**, Oregon Academy of Sciences *(joint award with Corinne Manogue)*

GRANTS

4/14 – 6/14	PERTG/AAPT (PI), *Workshop organizer grant*
9/13 – 8/16	NSF/DUE–1323800 (co-PI), *Representations of Partial Derivatives*
9/13 – 8/14	NSF/DUE–1256606 (PI), *Workshop supplement*
8/12 – 7/15	Templeton Foundation (PI), *An octonionic description of fundamental particles*
7/12 – 6/13	FQXi (PI), *A new look at the Freudenthal magic square*
9/10 – 8/14	NSF/DUE–1023120 (PI), *Interactive Electromagnetic Curricular Materials*
9/08 – 8/11	FQXi (PI), *Using Octonionic Cayley Spinors to Describe Fundamental Particles*
9/07 – 6/08	L. L. Stewart Faculty Development Award (OSU), *Teaching Calculus Coherently*
8/07 – 12/07	Hewlett Foundation mini-grant (OSU), *Teaching Calculus Coherently*
9/06 – 8/11	NSF/DUE–0618877 (co-PI), *Paradigms in Physics: Multiple Entry Points*
8/04 – 7/09	OMLI Disciplinary Content Team (funded by NSF/EHR–0412553)
2/04 – 9/08	ODE/Oregon ESEA Title II-B MSP 4076, (co-PI), *Central Oregon Consortium*
4/03 – 3/07	NSF/DUE–0231032 (PI), *Bridging the Vector Calculus Gap: Episode II*
1/01 – 7/03	NSF/DUE–0088901 (PI), *Bridging the Vector Calculus Gap*
6/00 – 6/01	OCEPT Faculty Fellow (funded by NSF/DUE–9996543)
1/00 – 6/01	L. L. Stewart Faculty Development Award (OSU), *Vector Calculus*
6/97 – 11/02	NSF/DUE–9653250 (senior personnel), *Paradigms in Physics*
9/96 – 6/97	L. L. Stewart Faculty Development Award (OSU), *Vector Calculus*
9/92 – 8/95	NSF/PHY–9208494 (co-PI), *The Wave Equation Isn't As Simple As You Thought*
8/94 – 6/95	OSU Research Council Award, *Algebraic Computing*
12/88 – 5/91	NSF/PHY–8813126 (PI), *Algebraic Computing in General Relativity*
11/89 – 5/90	OSU Research Council Award, *Algebraic Computing*

FELLOWSHIPS

2/95 – 8/95	Fulbright Senior Scholar (*Adelaide*)
7–12/87; 7–8/88	Indo-American Fellow (*Madras, Bombay, & Bangalore*)
1/86 – 4/87	SERC Postdoctoral Research Fellow (*York*)
10/82 – 9/83	NATO Postdoctoral Fellow (*Berlin*)
8/78 – 12/79	DAAD Stipendiat (*München*)

SHORT-TERM VISITS

1/10 – 2/10	The Center for Science and Mathematics Education Research, University of Maine, Orono, ME, USA.
11/09	School of Mathematical and Statistical Sciences, Arizona State University, Phoenix, AZ, USA.
11/09	Institute for Mathematics and Education, University of Arizona, Tucson, AZ, USA.
7/07 – 8/07	Department of Mathematics and Physics, DigiPen Institute of Technology, Redmond, WA, USA.
12/04	Perimeter Institute for Theoretical Physics (PI), Waterloo, CANADA.
7/99	Scuola Internazionale Superiore di Studi Avanzati (SISSA), Trieste, ITALY.
6/97 & 8/98	Department of Physics, Reed College, Portland, OR, USA.
7/90 & 8/90	School of Mathematical Sciences, Queen Mary College, London, ENGLAND.
7/90 – 8/90	Physics Department, University of Crete, Iraklion, GREECE.
8/88	Tata Institute of Fundamental Research (TIFR), Bombay, INDIA.
7/88	Raman Research Institute, Bangalore, INDIA.
8/86	School of Mathematical Sciences, Queen Mary College, London, ENGLAND.
12/85	School of Natural Sciences, Institute for Advanced Study, Princeton, NJ, USA.

MEMBERSHIPS

American Association of Physics Teachers, College Park, MD, USA

American Mathematical Society, Providence, RI, USA

American Physical Society, College Park, MD, USA

Australasian Society for General Relativity and Gravitation, Canberra, AUSTRALIA

Indian Association for General Relativity and Gravitation, Pune, INDIA

International Society on General Relativity and Gravitation, Bern, SWITZERLAND

London Mathematical Society, London, ENGLAND

Mathematical Association of America, Washington, DC, USA

Oregon Academy of Sciences, Portland, OR, USA

PUBLICATIONS

As of Fall 2014, I have published 78 articles in refereed journals; this total does not include conference proceedings, refereed or otherwise, nor numerous book reviews. Of these articles, more than 60 are on mathematical physics and related topics, and more than 10 are on science education, focusing on the teaching of second-year calculus. My h-index is 23.

In addition, I have written four books, on special (2012) and general relativity (2014), on vector calculus (online only; 2009–2013), and on the octonions (2015).

A complete list can be found at `http://oregonstate.edu/~drayt/cv/pubs.html`.

INVITED TALKS

I have given invited talks in 20 countries on 6 continents, including colloquia in 3 departments (Mathematics, Physics, and Computer Science) here at OSU.

A complete list can be found at `http://oregonstate.edu/~drayt/cv/talks.html`.

CONFERENCES

I have co-organized three conferences, and special sessions at two further conferences; one of the latter was at a major international conference. I have also attended numerous conferences the world over, as invited speaker, session chair, and/or presenter of a contributed talk.

A complete list can be found at `http://oregonstate.edu/~drayt/cv/conferences.html`.

STUDENTS SUPERVISED

As of Fall 2014, 7 students have completed their Ph.D. degree, and 6 students their M.S. degree, under my supervision.

A complete list can be found at `http://oregonstate.edu/~drayt/cv/students.html`.

I have been a member of the Graduate Faculty in both the Department of Mathematics and the Department of Physics since 1988, in the College of Education since 2014, a member of the University Honors College Faculty since 2000, and was named Courtesy Faculty in the Department of Physics in 1993.

Much of this CV can be found online at `http://oregonstate.edu/~drayt/cv`*, including an up-to-date list of publications with links to copies of most of my recent work.*

RESEARCH RESULTS

Much of my early work involved *classical general relativity.* For instance, my dissertation confirmed the existence of solutions of Einstein's equations containing gravitational radiation and satisfying known "physical" boundary conditions — formulated in terms of a conformal structure on spacetime.

I also published a paper on a rotating version of the famous *twin paradox*, illustrating at an elementary pedagogical level the subtleties involved in working with rotating observers.

I then became interested in *algebraic computing in relativity*, in which computer algebra is used to classify exact solutions of Einstein's equations. I have always been intrigued by this use of computers to derive equations which are then solved by hand, not vice versa.

I have also done purely mathematical work in *differential geometry.* For instance, together with my student, Stuart Boersma, I introduced the concept of *parametric manifolds*, a generalization of the idea of surfaces. This geometric structure is well-suited to the study of rotation, and should have applications to quantum field theory as described by rotating observers.

I have been fortunate over the years to have collaborated with a number of world-class scientists. Foremost among these is Professor Gerard 't Hooft, recipient of the 1999 Nobel Prize in Physics and one of the most often cited physicists ever, with whom I was a postdoc for two years. Our first paper, describing the only known *2-body solution* in general relativity, has been cited more than 150 times.

I have also had the chance to work with Professor Paul Davies, recipient of the 1995 Templeton Prize and prolific author of popular science books, on *quantum field theory in curved space*, the attempt to generalize quantum theory to relativity. Together with Corinne Manogue, we resolved the apparent paradox that rotating particle detectors see particles in "the" vacuum; the analogous problem for linearly accelerating detectors is well-understood, and is related to the *Hawking effect*, in which quantum black holes create particles with a thermal spectrum.

In the early 1990s, I was part of a collaboration that proposed considering *signature-changing spacetimes*, which contain Euclidean regions. This idea was proposed simultaneously, in the context of early-universe cosmology, by a group led by Professor George Ellis, the recipient of the 2004 Templeton Prize. The Euclidean region is a possible model for the Big Bang, and a comparison of our approaches led to a long and fruitful collaboration between the two groups.

More recently, again together with Corinne Manogue, I have been studying the *octonions* with a view to describing the physics of fundamental particles. Intriguing results have been obtained regarding the eigenvalues of 3×3 Hermitian octonionic matrices, notably that they admit 6, rather than 3, real eigenvalues. Using division algebras to do Clifford algebra manipulations in suitable dimensions provides an elegant mathematical framework that, among other things, shows why superstring theory only works in certain dimensions. This approach has already led us to new insights in particle physics, based on our eigenvalue results. Notable among these is a dimensional reduction scheme which suggests that the octonionic Dirac equation may lead to 3 generations of leptons with single-helicity neutrinos, observed properties of nature which remain unexplained by current theories.

TEACHING STATEMENT

I have always loved to teach.

My specialty is geometry, and I have taught numerous geometry courses, ranging from graduate courses in differential geometry to undergraduate courses in non-Euclidean geometry. But geometry infuses every course I teach, not only advanced applications, such as special and general relativity, but also more elementary courses, such as calculus. I most enjoy, and am best at, teaching undergraduates at the upper-division level, and have developed a variety of advanced undergraduate courses, which are described in more detail below.

My student evaluations are consistently among the best in my department. I received the 2011 Loyd Carter Award for Outstanding and Inspirational Undergraduate Teaching (and was a finalist on three previous occasions), and the 2004 Frederick Horne Award for Sustained Excellence in Teaching Science, both from the College of Science at OSU, and have also received two teaching awards from the University Honors College. In 2014, I received the Elizabeth P. Ritchie Distinguished Professor Award, OSU's most prestigious teaching award, as well as the Distinguished Teaching Award for College or University Teaching of Mathematics from the Pacific Northwest Section of the MAA.

One of the courses I designed is a Writing-Intensive Course in non-Euclidean geometry, taken by prospective secondary school teachers as well as traditional math majors. This course, which satisfies OSU's degree requirement that every student take a writing course *in their major*, is unquestionably the most challenging, as well as the most rewarding, course I have ever taught. Several of the student papers written for this course have won campus awards; at least two have been published. Another course I developed is a mathematics course in general relativity, taken by both undergraduate and graduate students in both math and physics. This course presents a nonstandard introduction to the differential geometry of general relativity, with an emphasis on differential forms rather than tensors; a book based on my course notes was published in 2014. At the invitation of the physics department, I also designed and taught a course on reference frames (special relativity and Coriolis forces); a book based on my course notes was published in 2012.

Along the way, I have tried a variety of innovations in the classroom. My calculus recitations have been turned into extended labs involving small group activities, somewhat along the lines of the MathExcel project, which in turn is based on Uri Trisman's Emerging Scholars Program. I make regular use of "flash cards" (similar to clicker questions), along the lines of the ConcepTests originally developed for other disciplines, which break up the tedium of a large lecture. I have used computer demonstrations in classes large and small, and several of my classes have involved student work in computer labs. But my favorite teaching aid remains the one I started with: colored chalk!

EDUCATION RESEARCH STATEMENT

I consider myself to be more of a curriculum developer than an education researcher, although I have increasingly been involved in work at the interface between these disciplines.

I have had the good fortune to be a part of the NSF-funded effort to redesign the physics major here at OSU, known as the *Paradigms in Physics* project. In this project, the junior-year courses were replaced by intensive, cross-disciplinary “paradigms”, which are followed in the senior year by more traditional, discipline-specific “capstones”. The intensive nature (7 hours per week) of the junior-year courses forced us to become experts in active engagement; 2-hour classes are too long for traditional lectures.

My curricular focus has been the transition from lower-division mathematics courses, especially second-year calculus, to upper-division physics courses, such as electromagnetism and thermodynamics. I directed the NSF-funded project entitled *Bridging the Vector Calculus Gap*, whose goal was to better incorporate the way vector calculus is actually used by physicists and engineers into the teaching of this material by mathematicians. Related work continues under the auspices of the Paradigms project, which, for the last several years, has been studying student learning of partial derivatives, and in particular student difficulties in transferring their mathematical knowledge to a physics context. I also serve on the National Advisory Committee for the NSF-funded project entitled *Raising Calculus to the Surface*, which has developed model surfaces and corresponding contour maps for use in multivariable calculus classes.

My primary role in these projects has been to develop and test classroom materials that are intended to help students gain a conceptual understanding of mathematical techniques, so that they can apply these techniques successfully in later physics courses. These materials include a large collection of small group activities, an accompanying instructor’s guide, and the ongoing development of a freely-available online text, covering both multivariable and vector calculus as well as some topics from junior-level physics courses, notably electromagnetism. We have been invited to give numerous workshops on the use of our materials, including several at major national meetings. One underlying theme in all of these materials is geometric visualization, which encourages conceptual reasoning involving multiple representations, rather than mere symbolic manipulation.

In addition, I have been involved with two projects aimed at increasing the mathematics content knowledge of K–12 teachers in rural Oregon, namely the High Desert Mathematics Partnership, and the Oregon Mathematics Leadership Institute. For the latter project, a Mathematics and Science Partnership funded at both the national and state level, I developed a minicourse in non-Euclidean geometry for in-service teachers. The goal of this course was only indirectly related to its nonstandard content, the idea being to model for teachers how to create a classroom culture of mathematical discourse.

In recent years, the Paradigms group has been using qualitative methods to study how students learn to apply mathematical techniques to problems in other disciplines, notably physics. Through interviews with both experts and students, we are developing models for student understanding of partial derivatives, focusing on the dramatic shift in usage that occurs between single-variable and multivariable calculus. Preliminary results also suggest the need to explicitly address the different notions of “small enough” that occur in different disciplines. Work on these topics is ongoing.