Todd Kemp

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Born: 1978 in Calgary, Canada
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EMPLOYMENT

UC San Diego	Professor	2018 – present
UC San Diego	Associate Professor	2014 – 2018
UC San Diego	Assistant Professor	2009 – 2014
MIT	Visiting Assistant Professor	2009 – 2010
MIT	CLE Moore Instructor	2006 – 2009
Cornell University	Escobar Assistant Professor	2005 – 2006

EDUCATION

PhD	Cornell University, Mathematics (Advisor: Leonard Gross)	2000 – 2005
MS	Cornell University, Mathematics	2000 – 2002
BSc	University of Calgary, Pure Mathematics, Applied Mathematics, and Physics	1996 – 2000

RESEARCH INTERESTS

Probability Theory, *Mathematical Physics*, *Functional Analysis*, and *Combinatorics*: random matrix theory and free probability; stochastic analysis; quantum information theory; Yang–Mills theory; analysis on Lie groups; functional inequalities (esp. logarithmic Sobolev inequalities); holomorphic and subharmonic function spaces; combinatorics of set partitions.

GRANTS AND AWARD

NSF Grant DMS-1800733: $210,000 supporting my research program at UCSD. (2018-2021)
Academic Senate Distinguished Teaching Award: for outstanding teaching at UCSD. (2018-2019)
CDIIP Grant: $45,000 supporting my development of online resources for linear algebra. (2018-2019)
NSF CAREER Award DMS-1254807: $550,000 supporting my research program at UCSD. (2013-2018)
Hellman Fellowship: $26,585 research award for young faculty at UCSD. (2011-2012)
NSF Grant DMS-1001894: $123,500 supporting my research program at UCSD. (2010–2013)
NSF Grant DMS-0701162: $117,000 supporting my research program at MIT. (2007–2010)
NSERC PGS: Graduate research fellowship from the Government of Canada. (2002-2004)
Sir James Lougheed Award: Graduate research fellowship from the Government of Alberta. (2002–2004)
Robert John Battig Award: Cornell Mathematics award for outstanding graduate research. (2002)
New Sage Fellowship: Graduate fellowship from Cornell University. (2000-2002)

PUBLICATIONS

All available at www.math.ucsd.edu/~tkemp/research.html, and on the ArXiv.

(1) **Kemp, T.**: *Hypercontractivity in non-commutative holomorphic spaces.* CMP **259** 615–637 (2005)
(2) **Kemp, T.**; Speicher, R.: *Strong Haagerup inequalities for $\mathscr{R}$-diagonal elements.* JFA Anal. **251** 141–173 (2007)
(3) **Kemp, T.**: *$\mathscr{R}$-diagonal dilation semigroups.* Math. Z. **264** 111–136 (2010)
(4) Graczyk, P.; **Kemp, T.**; Loeb, J.: *Hypercontractivity for log-subharmonic functions.* JFA **258** 1785–1805 (2010)
(5) Haagerup, U.; **Kemp, T.**; Speicher, R.: *Resolvents of $\mathscr{R}$-diagonal operators.* TAMS **362**, 6029–6064 (2010)
(6) **Kemp, T.**; Mahlburg, K.; Rattan, A.; Smyth, C.: *Enumeration of non-crossing pairings on bit strings.* J. Comb. Theory A. **118**, 129–151 (2011)
(7) Gryc, W.; **Kemp, T.**: *Duality in Segal-Bargmann Spaces.* JFA **261** 1591–1623 (2011)
(8) **Kemp, T.**; Nourdin, I.; Peccati, G.; Speicher, R.: *Wigner Chaos and the Fourth Moment.* Ann. Prob. **40**, 1577–1635 (2012)

(9) Driver, B.; Hall, B.; **Kemp, T.**: *The Large-N Limit of the Segal-Bargmann Transform on $\mathbb{U}_N$.* JFA **265** no. 11, 2585–2644 (2013)
(10) Collins, B.; **Kemp, T.**: *Liberation of Projections.* JFA **266** no. 4, 1988-2052 (2014)
(11) Gryc, W.; **Kemp, T.**: *On sharp constants for dual Segal–Bargmann L^p spaces.* J. Math. Anal. Appl. **424**, no. 2, 1198-1222 (2015)
(12) Graczyk, P.; **Kemp, T.**; Leob, J.: *Strong logarithmic Sobolev inequalities for log-subharmonic functions.* Canad. J. Math. 67 (6), 1384-1410 (2015)
(13) **Kemp, T.**: *The Large-N Limits of Brownian Motions on $\mathbb{GL}_N$.* Int. Math. Res. Not. IMRN, no. 13, 4012-4057 (2016)
(14) **Kemp, T.**: *Heat Kernel Empirical Laws on $\mathbb{U}_N$ and $\mathbb{GL}_N$.* J. Theoret. Probab. 30, no. 2, 397-451 (2017)
(15) Driver, B.; Hall, B.; **Kemp, T.**: *Three proofs of the Makeenko-Migdal equation for Yang-Mills theory in the Plane.* Comm. Math. Phys. 352, no. 3, 967-978 (2017)
(16) Driver, B.; Gabriel, F.; Hall, B.; **Kemp, T.**: *The Makeenko-Migdal equation for Yang-Mills Theory on Compact Surfaces.* Comm. Math. Phys. 352, no. 3, 967-978 (2017)
(17) Gour, G.; **Kemp, T.**: *The Minimum Renyi Entropy Output of a Quantum Channel is Locally Additive.* Lett. Math. Phys. 107, no. 6, 1131-1155 (2017)
(18) Collins, B.; Dahlqvist, A.; **Kemp, T.**: *The Spectral Edge of Unitary Brownian motion.* Probab. Theory Related Fields. 170, no. 1-2, 49-93 (2018)
(19) Friedland, S.; **Kemp, T.**: *Most Boson Quantum States are Almost Maximally Entangled.* Proc. Am. Math. Soc. 146, no. 12, 5035-5049 (2018)
(20) Gryc, W.; **Kemp, T.**: *Corrigendum to "On Sharp Constants for Dual Degal–Bargmann L^p Spaces.* J. Math. Anal. Appl. 475, no. 2, 1992-1995 (2019)
(21) Hall, B.; **Kemp, T.**: *Brown Measure Support and the Free Multiplicative Brownian Motion.* To appear in Adv. Math. (2019)
(22) Driver, B.; Hall, B.; **Kemp, T.**: *The Complex Time Segal–Bargmann Transform.* To appear in J. Funct. Anal.
(23) Cébron, G.; **Kemp, T.**: *Fluctuations of Brownian Motions on $\mathbb{GL}_N$.* In revisions.
(24) **Kemp, T.**; Zimmermann, D.: *Random matrices with log-range correlations, and log-Sobolev inequalities.* In revisions.
(25) Driver, B.; Hall, B.; **Kemp, T.**: *The Brown Measure of the Free Multiplicative Brownian Motion.* Preprint.

PRESENTATIONS Complete list at `www.math.ucsd.edu/~tkemp/presentations`.

Colloquium Lectures, 2012 - present

Temple University. Philadelphia, PA. April, 2019.
DePaul University. Chicago, IL. April, 2018.
University of Illinois, Urbana-Champaign. Urbana, IL. April, 2018.
University of Calgary. Calgary, Canada. March, 2017.
University of Illinois, Chicago. Chicago, IL. September, 2016.
University of Virginia. Charlottesville, VA. March, 2016.
University of Southern California. Los Angeles, CA. February, 2016.
University of Calgary. Calgary, Canada. November, 2015.
UCLA. Los Angeles, CA. April, 2015.
UC San Diego. La Jolla, CA. October, 2013.
The George Washington University. Washington, DC. February, 2013.
Iowa State University. Ames, IA. February, 2013.
University of Connecticut. Storrs, CT. Janaury, 2013.
UC San Diego. La Jolla, CA. October, 2012.
Fullerton College. Fullerton, CA. April, 2012.
University of Notre Dame. South Bend, IN. February, 2012.

Seminar Lectures, 2012 - present

Probability Seminar, University of Southern California. Los Angeles, CA. February, 2019.
Probability Seminar, UCLA. Los Angeles, CA. February, 2019.

Stochastics Seminar, University of Utah. Salt Lake City, UT. August, 2018.
Optimization and Data Science Seminar, UC San Diego. La Jolla, CA. May, 2018.
Felix Klein Seminar in Geometry, University of Notre Dame. South Bend, IN. October, 2017.
Probability Seminar, MIT. Cambridge, MA. September, 2017.
Quantum Information Seminar, UC San Diego. La Jolla, CA. June, 2017.
Functional Analysis Seminar, University of California, Los Angeles. Los Angeles, CA. May, 2017.
Stochastics Seminar, University of Utah. Salt Lake City, UT. September, 2016.
Probability Seminar, Northwestern University. Evanston, IL. September, 2016.
Probability Seminar, University of British Columbia. Vancouver, Canada. September, 2016.
Probability Seminar, Stanford University. Palo Alto, CA. May, 2016.
Probability Seminar, UC San Diego. La Jolla, CA. May, 2015.
Computational Finance Seminar, Carnegie Mellon University. Pittsburgh, PA. April, 2015.
Probability Seminar, University of Washington. Seattle, WA. January, 2015.
Probability Seminar, University of Luxembourg. Luxembourg City, Luxembourg. September, 2014.
Free Probability Seminar, Unversität des Saarlandes. Saarbrücken, Germany. September, 2014.
Analysis Seminar, Cornell University. Ithaca, NY. April, 2014.
Communication Theory Seminar, ECE UC San Diego. La Jolla, CA. February, 2014.
Analysis Seminar, University of Victoria. Victoria, Canada. February, 2014.
Analysis Seminar, University of Calgary. Calgary, Canada. September, 2013.
Analysis Seminar, Northwestern University. Evanston, IL. October, 2012.
Probability Seminar, University of Illinois. Urbana, IL. September, 2012.
Horowitz Seminar on Probability Theory, Tel Aviv University. Tel Aviv, Israel. August, 2012.
Operator Theory Seminar, University of Toronto. Toronto, Canada. June, 2012.
Calderón-Zygmund Analysis Seminar, University of Chicago. Chicago, IL. May, 2012.

Invited Conference Lectures, 2012 - present

CRM Thematic Program on New Developments in Free Probability. Montréal, Canada. March, 2019.
West Coast Operator Algebras Seminar, Seattle University. Seattle, WA. October, 2018.
IPAM Workshop on Random Matrices and Free Probability Theory. Los Angeles, CA. May, 2018.
Joint Mathematical Meetings, Special Session on Advances in Operator Algebras. San Diego, CA. January, 2018.
AMS Sectional Meeting, Special Session on Advances in Operator Algebras. Riverside, CA. November, 2017.
Mathematical Congress of the Americas, Special Session on Free Probability. Montreal, Canada. July, 2017.
BIRS Meeting on Analytic versus Combinatorial in Free Probability. Banff (BIRS), Canada. December, 2016.
Mini-course: Random Matrices, Free Probability and Determinantal Processes. Lille, France. May, 2016.
Free Probability and the Large N Limit, V. Berkeley, CA. March, 2016.
Oberwolfach Workshop on Free Probability Theory. Oberwolfach, Germany. June, 2015.
Frontier Probability Days. (Plenary Speaker) Tuscon, AZ. May, 2014.
Free Probability and the Large N Limit, IV. Berkeley, CA. March, 2014.
Fields Institute Workshop on Noncommutative Distributions and Free Probability. Toronto, Canada. July, 2013.
ICMAT Workshop on Operator Spaces, Harmonic Analysis and Quantum Probability. Madrid, Spain. June, 2013.
AIM (ARCC) Workshop on Geometric Perspectives in Quantum Field Theory. Palo Alto, CA. April, 2013.
Joint Mathematical Meetings, AMS Special Session on Free Probability. San Diego, CA. January, 2013.
Harmonic Analysis and Probability. (Plenaray Lecture) Angers, France. September, 2012.

Conferences Organized

Networked Life: Celebrating the life and career of Fan Chung and Ron Graham. La Jolla, CA. January, 2016.
AMS Western Spring Sectional Meeting, Special Session on Stochastic Processes in Noncommutative Probability. Albuquerque, NM. April, 2014.
JMM, AMS Special Session on Free Analysis and Free Probability. Baltimore, MD. January, 2014.
Probability and Statistics Day, UC San Diego. La Jolla, CA. April, 2013.
JMM, AMS Special Session on Stochastic Analysis and Mathematical Physics: A Session in Honor of the 80th Birthday of Len Gross. New Orleans, LA. January, 2011.

ADVISING AND TEACHING

Graduate Research Advising I have one current PhD students, and three previous students.

Natasha Blitvic graduated with a PhD in Electrical Engineering and Computer Science from MIT in 2012. Her research is in noncommutative probability theory. In her dissertation, she introduced a new two-parameter family of (q,t)-Gaussian spaces, with relations to quantum physics, operator algebras, and combinatorics. She held postdoctoral positions at Vanderbilt University, UC Berkeley, and was then a Zorn Postdoctoral Fellow at Indiana University. She is currently a Lecturer (US equivalent: Associate Professor) at Lancaster University, UK.

David Zimmerman graduated with a PhD in Mathematics from UCSD in 2015. He was an ARCS Fellow from 2012-2015. His research was in logarithmic Sobolev inequalities, and random matrices. He has proved important results on logarithmic Sobolev inequalities for mollified compactly-supported measures, with applications to random matrix theory. He was a Dickson Instructor at the University of Chicago. He currently works for Raytheon in Los Angeles.

Ching Wei Ho graduated with a PhD in Mathematics at UCSD in 2018. He entered the program in Fall 2013, and advanced to candidacy in Spring 2015. His research is in free probability, asymptotic random matrix theory, and Segal–Bargmann analysis. He has proved interesting results on the complex analytic and stochastic analytic approaches to the large-N limit of the Segal–Bargmann transform in different contexts, and local limit theorems for random multi-matrix ensembles. He is currently a Zorn postdoctoral fellow at Indiana University.

Alice Chan is a PhD candidate in Mathematics at UCSD. She entered the program in Fall 2014, with an NSF Graduate Fellowship. She has written one preprint, on the large-N limit of the Segal–Bargmann transform over the groups $\mathrm{SO}(N)$, $\mathrm{SU}(N)$, and $\mathrm{Sp}(N)$.

Undergraduate Research Advising

CURE: Collaborative Undergraduate Research Experience. (UCSD Summer 2013 - present)
I coordinate a program (under the aegis of my NSF CAREER Award) for undergraduate research. Each summer, 4-5 math majors entering their third or fourth years of study work together on an intense 8-week research project, which is supervised by one graduate student research assistant and myself (along with Prof. Brendon Rhoades in 2013-2014, and Dr. Ian Charlesworth in 2018). Projects are in the realm of probability theory and combinatorics, and have significant theoretical and computational components. The nearly 30 participants have gone on to PhD programs at MIT, Princeton, U Chicago, Cornell, Duke, and many other top programs.

Honors Thesis on "Maximally Correlated Random Band Matrices" (UCSD Fall 2016 - Spring 2017)
I advised Jiayi (Jessie) Tong, a graduating probability and statistics major, on her honors thesis, studying random matrices with independent bands $\{X_{ij} : |i-j| = k\}_{k=0\ldots n-1}$ but correlated entries along each band. This work generalized several papers on random Töplitz matrices, and suggested interesting new spectral distributions that may arise in these models. She was awarded High Honors for her project. In Fall 2016, she began a Masters program in statistics at Columbia University.

Honors Thesis on "Card Shuffling: Commuting Random-to-Random Shuffles" (UCSD Fall 2011 - Spring 2013)
I advised Camille Briat, a graduating probability and statistics major, on her honors thesis, studying the Markov chains given by random-to-random card shuffling techniques. Her work was both probabilistic and combinatorial, and suggested a new proof of a result about the commutativity of these processes. She was awarded the Silagi Prize, awarded each year to the best student graduating in all of science at UCSD. In Fall 2013, Camille began her PhD in mathematics as a MacCracken Fellow at the Courant Institute.

UROP on "Vector Fields on the 3-Sphere" (MIT Summer 2009 - Summer 2010)
As part of MIT's UROP (Undergraduate Research Opportunities Program), I advised a rising sophomore, Lauren McGough, in a year-long project on vector fields on spheres. She resolved a special case of an old conjecture, showing that any linear 3-field on the 3-sphere can be continuously deformed into a special orthonormal 3-field. She went on to complete a PhD in physics at Princeton University, with an NSF Graduate Fellowship.

REU on "Free Probability and Combinatorics" (Cornell Summer 2007)
I ran a very successful NSF REU (Research Experience for Undergraduates) project in summer 2007 at Cornell University. The aim of the project was to introduce a group of undergraduate students to combinatorial aspects of free probability theory, and engage in group projects to resolve functional analytic conjectures with enumerative techniques. The participants all went on to enter highly-ranked PhD programs.

Graduate Courses Taught

Stochastic Differential Equations (Math 286: UCSD Fall 2018)
In Fall 2018, I taught Math 286, an advanced graduate course on stochastic integration and stochastic differential equations. Topics included the stochastic integral with respect to a square integrable martingale integrator, the Ito / Doleans isometry, extension to local martingales and semi-martingales, quadratic variation and the Doob-Meyer decomposition, Ito's formula with applications to stochastic processes, the Feynman-Kac formula and other applications to PDE and harmonic analysis, Brownian local time, martingale representation theorems, and introduction to stochastic differential equations: strong existence and uniqueness for locally Lipschitz and sublinear growth drift and diffusion, weak solutions, and the Cameron-Marton-Girsanov theorem. We loosely follows the textbook "Introduction to Stochastic Integration" by Chung and Williams.

Lie Groups (Math 251BC: UCSD Winter & Spring 2015, 2019)
A two quarter graduate introduction to Lie groups, Lie algebras, and representation theory. Topics included smooth homomorphisms, smooth group actions, left invariant vector fields and Lie algebras, the exponential map, the Baker-Campbell-Hausdorff formula, the closed subgroup theorem, the Lie correspondence, quotients and covering groups, homogeneous spaces, the Lie-Cartan theorem, compact Lie groups, the Weyl group, Cartan's torus theorem, the Weyl integration formula, representation theory of $\mathfrak{sl}(n, \mathbb{C})$, representative functions and characters, and the Peter-Weyl theorem. I sampled from many sources and synthesized my own lecture notes.

Differential Geometry (Math 250A: UCSD Fall 2014, 2018)
First graduate quarter course introducing differentiable manifolds. Topics included differentiable manifolds, partitions of unity, submanifolds, imbeddings and immersions, tangent maps and the tangent bundle, vector fields, flows, cotangent bundle, tensor fields, and differential forms. Textbook: *Introduction to Smooth Manifolds* by John M. Lee.

Quantum Mechanics for Mathematicians (Math 247A: UCSD Spring 2017)
A one quarter graduate topics course I designed, on the basics of (non-relativistic) quantum mechanics, from a rigorous functional analytic perspective. Topics included a review of classical mechanics (Newtonian and Hamiltonian formulations), the key experiments of the early 20th Century that necessitated quantum mechanics, the Bohr–de Broglie "old quantum theory", the position and momentum operators (with careful domain analysis), the "axioms" of quantum mechanics, Schrödinger's equation, detailed analysis of the free Schrödinger equation, the quantized harmonic oscillator, the Heisenberg uncertainty principle, the spectral theorem for unbounded self adjoint operators, representation theory of $\mathrm{SO}(3)$, and the bound states of the Hydrogen atom. This was a *very* popular course, with almost 60 students initially signed up (and more than 25 finishing the course, despite a term paper and final exam being added to dissuade those who were not fully invested). Textbook: *Quantum Theory for Mathematicians* by Brian C. Hall.

Functional Analysis (Math 241AB: UCSD Fall 2016 & Winter 2017)
A two quarter graduate introduction to functional analysis. Topics included Hilbert spaces and Banach spaces and linear operators between them, the spectral theorem (for compact operators on Banach space; for bounded normal operators on Hilbert space), unbounded operators and the spectral theorem (for self-adjoint operators), Banach algebras, C^*-algebras, locally convex vector spaces, and weak topologies. Textbook: *A Course in Functional Analysis* by John B. Conway.

Introduction to Random Matrix Theory (Math 247A: UCSD Fall 2011 & Fall 2013)
Topics graduate course I designed. Wigner matrices, Wigner's semicircle law (with reduced moment assumptions) via combinatorial methods, convergence of the largest eigenvalue. The Cauchy-Stieltjes transform and vague convergence, Wigner's law (complex analytic techniques). Logarithmic Sobolev inequalities, concentration of measure; concentration for eigenvalues of Wigner matrices. Gaussian random matrices: genus expansion; change of variables and joint distribution of eigenvalues and eigenvectors; Vandermonde determinant and Hermite kernel; empirical eigenvalue distribution. Fluctuations of the largest eigenvalue: hypercontractivity, Ledoux's argument; Harer-Zagier recursion and optimal tail bounds. The Tracy-Widom Law and level spacing of zeroes.

Complex Analysis (Math 200ABC: UCSD Fall 2012 – Spring 2013)
Standard full-year sequence of core graduate courses on complex analysis (in one complex variable). Topics included complex numbers and functions, Cauchy's integral formula and its applications, calculus of residues, expansions of analytic functions, analytic continuation, conformal mapping and Riemann mapping theorem, Carathéodory's theorem, harmonic functions, Dirichlet principle, Hardy spaces, and Bergman spaces. Textbooks: *Functions of One Complex Variable, Volumes I and II* by John B. Conway, and *Function Theory of One Complex Variable* by Robert Greene and Steven Krantz.

Stochastic Processes (Math 285: UCSD Spring 2012)
A graduate course introduction to stochastic processes, without measure theory. Topics included Markov chains (finite and countable state space), hidden Markov models, martingales, Brownian motion, and Gaussian processes. Textbook: *Introduction to Stochastic Processes, 2nd Edition* by Greg Lawler.

Introduction to Free Probability (Math 247A: UCSD Spring 2011)
Topics graduate course I designed. General noncommutative probability, introduction to C^*-algebras and the GNS construction, free independence, free product constructions; partition lattices, non-crossing partitions, Möbius inversion in lattices, free cumulants, the Stieltjes transform and the $\mathscr{R}$-transform; asymptotic freeness of random matrices. Textbook: *Lectures on the Combinatorics of Free Probability* by Alexandru Nica and Roland Speicher.

Probability Theory (18.175: MIT Spring 2009)
Basic probability theory, laws of large numbers, central limit theorems, introduction to martingales, Brownian motion, and basics of Lévy processes. Textbook: *Probability: an analytic view* by Dan Stroock.

Measure and Integration (18.125: MIT Spring 2008)
Basic measure theory, Lebesgue integration theory, L^p spaces and basic functional analysis, and elements of Fourier analysis. Textbooks: *A Concise Introduction to the Theory of Integration* by Dan Stroock and *Real and Complex Analysis* by Walter Rudin.

Stochastic Analysis (18.177: MIT Fall 2007)
Brownian motion, martingales and stochastic integration; Malliavin calculus on Euclidean space and its application to PDE. Textbooks: *Brownian Motion and Stochastic Calculus* by Ioannis Karatzas and Steven Shreve, and *The Malliavin calculus and related topics* by David Nualart.

Topics in Functional Analysis (Math 712: Cornell Spring 2004)
Topics graduate course I designed, "Compact operators on Hilbert space," detailing the classical theory of Schatten p-ideals. The course (three one-hour lectures per week for the fourteen week term) was regularly attended by nine graduate students and two faculty members.

Undergraduate Courses Taught

Linear Algebra (Math 18 / 20F: UCSD Fall 2012, Winter 2017, Winter 2018)
Standard first linear algebra quarter course, covering matrix algebra, Gaussian elimination, determinants. Linear and affine subspaces, bases of Euclidean spaces, eigenvalues and eigenvectors, quadratic forms, orthogonal matrices, diagonalization of symmetric matrices; computing symbolic and graphical solutions using Matlab. Textbook: *Linear Algebra and its Applications* by David Lay.

Introduction to Probability (Math 180A: UCSD Fall 2010 & Winter 2016)
Probability spaces, random variables, distribution, expectation, independence; combinatorial probability;

inclusion-exclusion, conditional probability, Bayes' theorem; joint marginal and conditional distributions; cumulative distributions and densities; law of large numbers; central limit theorem. Textbook: *Elementary Probability for Applications* by Rick Durrett.

Real Analysis (18.100B/C: MIT Fall 2008 & Spring 2010, Math 140AB: UCSD Winter 2014, 2016)
The first course in real analysis, with topics including topology of metric spaces, continuity and differentiability on the real line, the Riemann-Stieltjes integral, and sequences and series of functions. Textbook: *Principles of Mathematical Analysis* by Walter Rudin (which he wrote for this course while at MIT). [18.100C has the same course content as 18.100B, but an extra hour of face-time per week and more written work for the students, to satisfy communication requirements in the math major.]

Vector Calculus (Math 20E: UCSD Fall 2014)
Standard vector calculus in 2 and 3 dimensions, with topics including change of variables in multiple integrals, Jacobian, line integrals, Green's theorem, vector fields, gradient fields, divergence, curl, spherical/cylindrical coordinates, Taylor series in several variables, surface integrals, Stokes's theorem, Gauss's theorem, and conservative fields. Textbook: *Vector Calculus, 6th Edition* by Jerrold Marsden and Anthony Tromba.

Multivariate Calculus (18.022: MIT Fall 2009, Math 20C: UCSD Fall 2011)
Standard multivariate calculus in 2 and 3 dimensions, with topics including basic linear algebra, continuity and differentiability of multivariate functions, parametrized curves, vector fields, grad, div, and curl, multiple integrals; 18.022 at MIT also included line and surface integrals, manifolds with boundary, and Stokes's theorem. Textbooks: *Calculus: Early Transcendentals, 2nd Edition* by Jon Ragowski at UCSD; *Vector Calculus, 3rd Edition* by Susan Colley at MIT.

Theoretical Calculus (Math 223/224: Cornell 2005/2006, 18.014/18.024: MIT 2006/2007)
Standard material in first and second year courses in calculus and multivariate calculus, at a theoretical level with additional topics (such as a self-contained treatment of linear algebra, and differential forms). Textbooks: *Calculus: Volumes I and II* by Tom Apostol (augmented by significant course-notes in the second term) at MIT; *Vector Calculus, Linear Algebra, and Differential Forms: A Unified Approach* by John Hubbard and Barbara Hubbard at Cornell.

Calculus II (Math 112: Cornell Summer 2002)
The second semester of first-year calculus in the summer, covering integral calculus and sequences and series. Textbook: *Calculus* by Robert Adams.

SERVICE AND OUTREACH

Teaching Committees. (2018 - present)
I am the chair of the SEW postdoc teaching committee, and a member of the faculty teaching committee in the math department at UCSD. We do teaching observations an assessment of instructors in the department and give additional pedagogical support and advice. As the SEW teaching chair, I am designing and implementing a new teacher training and support program, as our postdoc program grows.

Dean of Physical Science Development Committee. (2017 - present)
I serve on the Development Committee for the Dean of Physical Sciences. This is an executive advisory committee with three invited senior faculty from each of the mathematics, physics, and chemistry departments. We advise the Dean on matters of divisional importance, in particular evaluating funding requests for academic ventures within the division and across the university.

Dean Review Committee. (2018)
I am an appointed member of the 8-person Five Year Review committee for Prof. Mary Alshok, Dean of the UC San Diego Extension Program.

San Diego Honors Math Contest. (2011 - 2018)
I was the liaison from the UCSD math department to the Greater San Diego school district. In that capacity, I coordinate and write the annual San Diego Honors Math Contest (which has run since 1958). More than

200 high school students write the two-part exam each year. I also coordinate grading, and an awards banquet for the event.

Curriculum Redesign. (2013 - 2017)
I undertook a project, jointly with Senior Teaching Professor John Eggers, to significantly change the structure of the lower division undergraduate engineering-and-science-streamed courses offered by the math department (the Math 20 sequence). Formerly, the course in Linear Algebra, Math 20F, had been the last course in the sequence of six, and actually had multivariate calculus (Math 20C) as a prerequisite. This was at odds with almost all of UCSD's peer institutions, and was more than awkward from a pedagogical standpoint. After significant conversations with people in math, physics, chemistry, and various engineering departments, it became clear nobody really knew the original reasoning. Over the course of several years, I prepared a plan to change the curriculum to have Linear Algebra first (which entailed *positive* pedagogical changes throughout several of the courses and a lot of administrative changes), and a proposal extensively studying its effects. In Winter 2016, the math department accepted this proposal, and then it was referred to the Undergraduate Council of the whole university. It received positive support from many departments, and it became official in Fall 2016. Linear Algebra is now taught as Math 18, the first course in the sequence, and is a prerequisite for vector calculus (Math 20E). I am closely following student outcomes in the new curriculum and I am so far very pleased with the positive effects it has had.

Graduate Admissions. (2014 - 2017)
I served on the graduate admissions committee for the UCSD PhD program. In that capacity, I reviewed nearly 100 applications in probability and analysis each year, and participated in ranking discussions for admission of prospective students. I also spearheaded a new initiative to attract more highly ranked and minority candidates with a combination of longer fellowships and campus incentives, which proved very effective.

Undergraduate Honors & Awards. (2017)
I served on the committee that decided on the status of the Math 199H honors theses submitted by the graduating majors in 2017. This involved reading 5 honors theses (totaling more than 180 pages), attending the students' presentations, and debating the standing of the theses with the committee of three faculty members.

Undergraduate Colloquium. (2011)
I organized the undergraduate colloquium for math majors at UCSD in Fall 2011. This involved finding speakers (mostly from within the department) to give weekly talks about their current research, made accessible to an audience of junior and senior math majors. I also gave the introductory lecture in the series (on random matrix theory and planar diagrams).

MIT Integration Bee. (2007 - 2009)
I organized and ran the MIT Integration Bee, which entailed writing a challenging qualifying written test (of integrals) and preparing a live round-robin tournament of integration. There were more than 100 contestants for the qualifying exam each year, and between 12-20 who qualified for the Bee. There were frequently several hundred spectators (including some who traveled from across the country), and one year the event was televised.

Reviews, Refereeing. (2005 - present)
I have served on NSF and NSERC panels, and reviewed applications for Simons grants. I have refereed several books and dozens of papers for journals including J. Funct. Anal., Commun. Math. Phys., J. Comb. Theory A, the Annals of Probability, Prob. Theory Related Fields, AIHP, Memoirs of the American Mathematical Society, the American Mathematical Monthly, and many others.

Ithaca High School Senior Math Seminar (2002)
I founded and co-taught this program to introduce high school students to advanced material that usually would not be covered in introductory college courses in mathematics. The Senior Seminar is now a highly-successful NSF-funded outreach program at Cornell; three graduate students teach it each term to fulfill their regular teaching duties.