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Engineering Mathematics Around the World

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The following is a list of some of the institutions worldwide that offer programs in engineering mathematics:

U.S.A.

California Institute of Technology, Department of Computing and Mathematical Sciences
- Applied and Computational Mathematics (B.S.)
- Applied and Computational Mathematics (Ph.D.)
- Computing and Mathematical Sciences (Ph.D.)

Columbia University, Applied Physics and Applied Mathematics with Materials Science and Engineering
- Applied Mathematics (B.S.)
- Applied Physics, Materials Science & Engineering (B.S./M.S./Ph.D.)

Harvard University, John A. Paulson School of Engineering and Applied Sciences
- Applied Mathematics (A.B., A.B./S.M.)
- Applied Mathematics (Ph.D.)

Johns Hopkins University, Applied and Computational Mathematics
- Applied and Computational Mathematics (M.S.)
- Post-Master's Certificate

New York University, Courant Institute of Mathematical Sciences
- Scientific Computing (M.S.)

Princeton University, The Program in Applied and Computational Mathematics
- Applied and Computational Mathematics (Certificate)

Stanford University, Institute for Computational & Mathematical Engineering
- Computational and Mathematical Engineering (M.S.)
- Computational and Mathematical Engineering (Ph.D.)

University of Texas at Austin, Institute for Computational Engineering and Sciences
- Computational Engineering and Sciences (M.S.)
- Computational Engineering and Sciences (Ph.D.)

ENGLAND

Oxford University, Mathematical Institute
- – Mathematical Modeling and Scientific Computing (M.Sc.)
- – Industrially Focused Mathematical Modeling (Doctoral Training)

University of Bristol, Department of Engineering Mathematics
- – Engineering Mathematics (B.Eng.)
- – Engineering Mathematics (M.Eng.)

ITALY

Politecnico di Milano, School of Industrial and Information Engineering
- – Mathematical Engineering (M.Sc.)

Politecnico di Torino, College for Engineering Mathematics. Department of Mathematical Sciences
- – Mathematics for Engineering (B.Sc.)

EUROPE

Chalmers University of Technology
- – Engineering Mathematics and Computational Science (M.Sc.)
- – Advanced Engineering Mathematics (Licentiate)

Ecole Polytechnique
- – Applied Mathematics (Bachelor's/Master's/Ph.D.)

KTH Royal Institute of Technology in Stockholm
- – Applied and Engineering Mathematics (N5TeAM)

Lund University
- – Engineering Mathematics (M.Sc.)

Technical University of Budapest
- – Research University Program

Technical University of Denmark
- – Applied and Engineering Mathematics (Nordic M.Sc.)

Technical University of Munich
- – Computational Science and Engineering (M.Sc.)

Uppsala University

– Master's Program in Computational Science (M.S.)

CHINA
Tsinghua University, Department of Mathematical Sciences

The term "engineering mathematics" comes from an era when physics, mechanics, and mathematics were more closely tied together. With the dawn of high-powered computing, larger data sets, and new mathematical methods, engineering mathematics departments have begun to branch out into more exotic interdisciplinary realms, leaving students with ever more compelling career options.

Engineering mathematics covers "a huge spectrum that runs from theoretical applied mathematics to strong, industrially-driven computations," said Margot Gerritsen, who leads the Institute for Computational and Mathematical Engineering (ICME) at Stanford University. "What one calls 'engineering mathematics' might be called 'applied mathematics' elsewhere. Everyone has their own flavor and different heroes, depending on where they sit on the spectrum."

Housed within the Stanford University School of Engineering, ICME is a multidisciplinary graduate-level institute with about 200 students and roughly 60 faculty members. The institute interacts with 20 academic departments across the university, including engineering, Earth sciences, and medicine.

"That sort of model, which is more university-wide, is not so common in Europe, where most institutes are organized by department and by definition are a bit more insular," Gerritsen said. "We try to be the web that glues all these people together, connecting mathematics to the applied sciences and engineering."

Founded in 2004, ICME has a long history of association with Stanford's Department of Computer Science. Before ICME, George Forsythe and Gene Golub created the "Numerical Analysis Group," which later became known as the Scientific Computation and Computational Mathematics Program. Nonetheless, even while Gerritsen was studying at Stanford in the early 1990s, the university was already considering the es hment of a separate institute that took a broader, more interdisciplinary app oach to computational mathematics.

ICME has moved beyond the traditional engineering mathematics discipline and offers a Ph.D and a two-year M.S. degree, which includes specialized tracks in computational geosciences, data science, imaging science, and mathematical and computational finance. The institute makes a point of training its graduates in both the theoretical and technical aspects of computational mathematics.

"We place students in computational groups in larger companies," Gerritsen said. "Companies want to build data mining and machine learning applications in-house, so they need to understand the engines involved."

To prepare students for industry, Stanford encourages internships through its industrial affiliate programs and participation in large projects through the Army High Performance Computing Research Center and the Predictive Science Academic Alliance Program II Center, among others. These projects cover a broad range of topics, including genomics, physiology, and Earth sciences.

"Students are consulting with companies on a regular basis and founding companies," Gerritsen said. "We are in the midst of Silicon Valley, which is computationally extremely heavy. Our students therefore must be good team players, excellent mathematicians, pretty good programmers, and have engineering sense."

Former Stanford Ph.D. student Ryan Lewis works at Ayasdi, a venture-backed machine intelligence software company that provides data analysis to the financial services and healthcare industries. His professor, Gunnar Carlsson—also a Stanford graduate—cofounded Ayasdi to commercialize his own foundational work in pure and applied computational topology. Carlsson appreciates how ICME transcends the traditional approaches to engineering mathematics.

"A lot of engineering mathematics has been about certain computational paradigms in linear algebra and differential equations," Carlsson said. "But ICME is moving beyond that to all kinds of stochastics and combinatorial and more discrete mathematics, so I think what you are seeing is a math program that is broadening what applied math means and doing a really good job of it."

Graduates of Stanford's related departments of computer science and mathematics have founded companies and become educators. 2013 Ph.D. graduate Reza Zadeh established his own machine-learning company called Matroid. Nick Trefethen studied computer science at Stanford and now heads the University of Oxford's Numerical Analysis Group. Google founders Larry Page and Sergey Brin both studied computer science at Stanford, and Gerritsen speculates that their grounding in numerical linear algebra may have played a role in their discoveries, including that of the page-ranking algorithm.

Founded in 2003, the University of Texas's Institute of Computational Engineering and Science (ICES) includes about 160 faculty and 70 students. A key professor in the institute, Mary Wheeler, works on the theoretical side of engineering mathematics in the oil and gas industry. "Companies don't want to prove theorems," Wheeler said. "Generally in engineering, you see more of applying the research and invalidating or verifying it."

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Margot Gerritsen (right) acknowledges students who made special contributions to the community at "ICME Xtravaganza," Stanford University's year-end celebration with the Institute for Computational and Mathematical Engineering community, in May 2016. Photo credit: Ana Santos.

The interdisciplinary Computational Science, Engineering, and Mathematics (CSEM) program at ICES offers M.S. and Ph.D. degrees and includes concentrations in numerical analysis and mathematical modeling. Students work with researchers from diverse departments, performing field tests and experiments to create predictive mathematical models, such as the injection of CO_2 into demonstration sites.

Wheeler also leads an Industrial Affiliates Program to help students better understand industrial challenges. The program has connections to roughly 10 companies, including IBM and various oil and environmental corporations.

On the other side of the Atlantic, the University of Bristol's Department of Engineering Mathematics is also seeking to broaden the definition of engineering mathematics. The department, which is within the Department of Engineering, comprises roughly 220 undergraduate students and plans to establish an M.Sc. in engineering mathematics next year. Director Alan Champneys considers the title "engineering mathematics" to be sort of a misnomer, given its emphasis on mathematical and data modeling.

"It doesn't really conjure up an image of who we are," Champneys said. "Going back 40 or 50 years, it was about process modeling—about modeling mechanics and fluid flow—the traditional engineering mathematics. Now we are more into cool technology."

Some of these innovative technologies are in the subdisciplines of dynamical systems, artificial intelligence, biological modeling, and robotics. Senior lecturer Nathan Lepora, once a theoretical physicist and children's author, works at the cutting edge of neuroscience and robotics in a discipline called swarming behavior, which may prove useful in drug delivery and drone applications.

Academic options include a three-year B.Eng., a four-year M.Eng. (an integrated undergraduate and postgraduate program), and an M.Sc. (one year + summer program after B.Sc.) in robotics and autonomous systems. The program has four core areas: mathematics, computational science, general engineering, and hands-on mathematical modeling. Champneys says the program distinguishes itself from a standard engineering track with its advanced mathematics courses. He plans to launch a one-year M.Sc. in engineering mathematics next year.

Related to the Bristol Engineering Mathematics Department is the Bristol Centre for Complexity Science, a government-sponsored doctoral training program that has about 50-60 students completing Ph.Ds., with roughly half receiving supervision from engineering math faculty.

It was once common for graduates of the Bristol program to enter careers in financial services, Champneys said, but in the last several years they have begun to gravitate more toward technical consultancy, especially in renewable energy. Some of his students now work for Frazer-Nash Consultancy, a British technical consulting firm.

"There is a lot of work in defense and software," Champneys said. "There is a niche market for essentially being consultants who do mathematical modeling, and it doesn't matter what the domain is."

Every engineering math student has an industrial tutor from some company with which Bristol has connections. Thomas Melvin, who earned his Ph.D. from Bristol, works as a research scientist for the U.K. Meteorological (Met) Office, where he creates numerical models for weather prediction by starting with a very simplified mathematical model that he gradually augments based on ground, balloon, airplane, and ship observations.

To the north, Sweden is known as a powerhouse in the theory of engineering mathematics, through such universities as the Royal Institute of Technology (KTH) in Stockholm and Chalmers University of Technology in Gothenburg. Around 2005, Lund University began the first engineering mathematics program in Sweden. In 2008, Chalmers established a combined bachelor's and master's degree program in engineering mathematics and computational science with three tracks: computational science, mathematical statistics, and general mathematics.

"If you study at Chalmers, you really become an engineer," director Håkan Andreasson said. "It is required that you really receive some skills associated with engineering. We have students at the software company Ericsson doing electronics, and a number of students end up doing statistics or mathematical biology at AstraZeneca."

Jacob Leander studied engineering mathematics, graduating with an M.S. in engineering mathematics and a licentiate (half of a Ph.D) in advanced engineering mathematics after a combined five years. He wrote his thesis on the optimal design of clinical studies for drugs while interning two years at AstraZeneca in Gothenberg and working in collaboration with the Fraunhofer-Chalmers Centre for Industrial Mathematics, where he completed his licentiate project on data analysis and algorithm development. After graduation, Leander worked on car GPS systems at Volvo and later as a clinical pharmacometrician at AstraZeneca, where he now creates mathematical models to describe the effects of drugs that treat respiratory, inflammatory, and autoimmune diseases. He relies heavily on dynamical systems, statistics, and ordinary differential equations.

“I use my engineering background in a setting where most people don’t have that sort of detailed knowledge about the mathematics,” Leander said. “So I really enjoy it.”

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