Cambridge Mathematics

Mathematics is the historic subject at Cambridge. In the century following Newton it was made central to intellectual life in the University. An oral examination in Mathematics was introduced for all students, followed a little later by a major innovation: a series of written papers. This, the famous Mathematical Tripos, is the model for written university examinations in the modern world.

The Tripos became an intense training in mathematical technique and was spectacularly successful, nurturing a series of great mathematical scientists (Green, Stokes, Kelvin, Maxwell, Rayleigh, J.J. Thompson). But the 19th century Tripos seems strange today. There was no University or College teaching (private coaching filled the gap), and little encouragement to study anything outside a narrow range of exam questions. The system lasted until 1907 when major (and highly contentious) reforms modernised and broadened the syllabus.

Through the 20th century mathematics developed in tandem with the University, becoming thoroughly international in outlook. Departments were founded: Applied Mathematics and Theoretical Physics (DAMTP) in 1959, and Pure Mathematics and Mathematical Statistics (DPMMS) in 1964. In 2002 the Faculty came together in the new Centre for Mathematical Sciences, designed to encourage synergy between the Departments. Over these years the Mathematical Tripos has changed relatively little. We teach a more modern syllabus, but as the 1907 reformers wished, we still attempt to educate in mathematical understanding rather than cram for examinations. We still set hard problems, and the most common style of question, bookwork followed by a rider, would seem perfectly familiar to our predecessors.

Cambridge is the centre of a distinctive British style of applied mathematics, in which the mechanics of fluids and solids is prominent. Nowadays mathematical modelling of real fluid phenomena, deriving striking consequences from good simplifying assumptions,is supplemented by judicious use of computer simulation. Our interests include environmentally critical areas - the atmosphere, ocean and ice caps - and more exotic processes such as magnetoconvection in stars. The physics of the Earth is a longstanding concern: exciting work on volcanoes and the Earth's core is focused in the Institute of Theoretical Geophysics - a joint venture with Earth Sciences. A further strength is applied analysis encompassing numerical methods, order and chaos in non-linear systems, and the systematic derivation of approximate equations to describe real-world systems. We have exceptional expertise in practical questions: complex fluids in industrial processes, noise from jet engines, the flow of water round hulls and air over wings. Work in fluid mechanics is best linked to experiment, and the purpose-built G. K. Batchelor Fluid Dynamics Laboratory is in constant use.

Cambridge interest in general relativity and cosmology goes back to Eddington in the 1920s. The group led by Stephen Hawking is at the forefront of research. Hawking

famously discovered that black holes were not black; properties of black holes and the early universe remain major concerns. Cambridge quantum mechanics stems from Paul Dirac, Nobel Prizewinner for his foundational work. I vividly remember his 1969 Rouse Ball lecture in which he stressed that ideas such as his prediction of anti-matter were arrived at by considerations of mathematical elegance. Dirac's successors display the same spirit. A major challenge for theoretical physics is to reconcile general relativity and quantum mechanics. Cambridge is a world centre for work on major candidate theories, supergravity, string theory and its extensions to M-theory and D-branes. We also study applications of quantum physics, such as quantum computing and quantum fluids.

Pure mathematics, neglected in 19th century Cambridge, has blossomed since the 1907 reforms. Initial momentum came from Hardy and Littlewood who introduced rigorous analysis, and themselves made many important contributions to analytic number theory. Hardy's collaboration with Ramanujan is legendary. The University has maintained its reputation in hard analysis. Spectacular results on arithmetic progressions in the prime numbers have recently been obtained by analytic means. Researchers in this area are closely linked to a distinctive school of combinatorics built up in the last 30 years. The algebraic side of number theory, derives from Louis Mordell, who came in 1906 as a self-taught school boy to England from the US to take the Entrance Scholarship Examination. Mordell was followed by a long line of exceptional Cambridge researchers, and algebraic number theory is now a major speciality in DPMMS. The most celebrated achievement stemming from the Cambridge school is the proof by Andrew Wiles of Fermat's Last Theorem.

Cambridge algebra and geometry, originated with work of Philip Hall and William Hodge in the 1930s. Hodge revolutionised geometry by studying the equations of mathematical physics, and links he uncovered between analysis, geometry and physics still continue as the focus of research. The more algebraic side of geometry has also seen spectacular progess in Cambridge recently. Hall had a major impact on modern group theory, and his successors were heavily involved in the classification of the finite simple groups. Five of the twenty-six mysterious sporadic groups bear their names and the central Monstrous Moonshine Conjectures were also Cambridge work. Our interests in algebra have diversified, with recent emphasis on connections with geometry and number theory.

In Cambridge many sciences (astronomy, physics, computer science) stemmed from mathematics, and other subjects (economics, philosophy) were influenced by mathematicians. But the traffic has not all been one way. Statistics began in the sciences in particular with the study of observational error in astronomy. The first appointments were in Agriculture; and the great statistician Fisher was Professor of Genetics from 1943. The Statistical Laboratory was founded as late as 1947, and was then incorporated in DPMMS. As statistics has become ever more important within the sciences, it has become imperative to give the subject greater focus, and a Statistics Initiative has been launched to do that. The Statistical Laboratory also encompasses all kinds of probability. The study of networks, fundamental for modern communication, is a particular strength, with links to computer science. A newer area, mathematical finance, shares interests with the Judge Institute of

Management. Finally modern biology has produced a range of mathematical challenges with serious statistical content. The Cambridge Computational Biology Institute has been set up in DAMTP to promote research. Mathematical biology offers research opportunities to both Departments and is the most recent subject area to be introduced in the Mathematical Tripos.

With exhilarating progress being made in established areas, and the introduction of fresh applications Cambridge mathematics is active on a broad front. This breadth is a strength as major progress often involves connections between apparently unrelated phenomena, and finding such links counters the centrifugal tendencies inherent in so extensive a subject. Benefits are also felt by undergraduates. The Mathematical Tripos covers a greater intellectual range than any comparable mathematics course. Most of our students will find some area which particularly appeals to them and in which they can shine.

Breadth demands openness and a toleration of difference, and that is part of our inheritance. Our undergraduates still come largely from the UK, and what we care about at this level is sheer mathematical aptitude; but in research, we welcome the very best wherever they come from - about half our research students are from abroad. In return we export our own. Cambridge mathematicians are found all over the world. What Cambridge gave and still gives is opportunity: the opportunity to learn and research in an environment which cherishes independent ideas; and the opportunity and the encouragement to excel.