

Introduction to the Computational Applied Mathematics MSc programme





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Welcome to Edinburgh

- Historic and cultured city of breath-taking beauty and world-class attractions
- Population of 500,000, around one tenth are students
- Year-round destination and festival city
- UNESCO World Heritage Site







School of Mathematics

- We are located in the James Clerk Maxwell Building at the King's Buildings campus in south Edinburgh.
- This is about 2.5km from main campus.
- About 35 min walk, 20 min bus, 10 min cycle.
- Around 100 academic research and teaching staff and over 145 PhD students.
- Around 2000 undergraduate students.
- Around 200 MSc students each year, of which around 30 study the CAM MSc.









CAM MSc: Key areas

- Computational methods and techniques
- Numerical methods
- High-level applied mathematics
- Options in topics including:
 - Machine learning and data science
 - Statistics
 - Optimization







CAM MSc: Student cohort

- Super cosmopolitan cohort
- ~30 students in recent years
 - Austria

Ireland

- Azerbaijan
- Bulgaria
- China
- Cyprus
- India

- Japan
- Malaysia
- Mexico
- United Kingdom
- USA







CAM MSc: How is it different to undergraduate maths?

- One year degree
- Full 12 months of study
- More intense study
- More focused on the subject area
- Two semesters of courses (120 credits)
- Followed by a substantial summer dissertation (60 credits)





Current core courses

- Applied dynamical systems (S2)
- Numerical linear algebra (S1)
- Numerical partial differential equations (S2)
- Python programming (S1)
- Research skills in Computational Applied Mathematics (S1 & S2)







Semester 1: Optional Courses

- Applied stochastic differential equations
- Bayesian theory
- Fundamentals of optimization
- Industrial mathematics
- Introductory probability and statistics (introductory course)
- Statistical methodology (introductory course)
- Statistical programming
- Stochastic modelling







Semester 2: Optional Courses

- Bayesian data analysis
- High performance data analytics
- Large scale optimization for data science
- Fluid dynamics
- Machine learning in Python
- Numerical ordinary differential equations and applications
- Optimization methods in finance
- Time series
- Numerical methods for data
- Numerical methods for uncertainty quantification
- Nonlinear optimization







Taught component: credits

- 120 credits of taught courses
- 60 credits in semester 1 (Sep-Dec, Dec exams)
- 60 credits in semester 2 (Jan-Apr, May exams)
- Full year Research Skills for Computational Applied Mathematics (20 credits)
- 2 further core courses in each semester (10 credits each)
- 3 optional courses in Semester 1 (10 credits each)
- 3 optional courses in Semester 2 (10 credits each)





Typical week during the semester

- A semester consists of six 10 credit courses (five 10 credit courses + half of full year Research Skills). Typically:
 - Each course has 2 hourly lectures per week
 - Followed by an hour of tutorials every second week
 - The more computationally intensive courses also contain computer labs
- All lectures/workshops/labs take place at King's Buildings (typically the James Clerk Maxwell Building)





Sample timetable (Semester 1)

	09:00-10:00	10:00-11:00	11:00-12:00	12:00-13:00	13:00-14:00	14:00-15:00	15:00-16:00	16:00-17:00	17:00-18:00
Monday	Industrial Mathematics lecture				Python Programming lecture	Applied Stochastic Differential Equations lecture			
Tuesday			Numerical Linear Algebra lecture			Applied Stochastic Differential Equations lecture	Industrial Mathematics workshop		
Wednesday	Research Skills for Computational Applied Mathematics lecture		Numerical Linear Algebra workshop		Fundamentals of Optimization workshop (every 2 nd week)				
Thursday	Applied Stochastic Differential Equations workshop (every 2 nd week)		Fundamentals of Optimization lecture						
Friday	Numerical Linear Algebra lecture	Applied Stochastic Differential Equations computer workshop (every 3 rd week)				Python Programming workshop		Research Skills for Computational Applied Mathematics workshop (every 2 nd week)	





Dissertation component

After completing taught component, in June you start working on your summer dissertation project (60 credits).

Many different research areas to choose from. Examples might include:

- Mathematical biology
- Computational harmonic analysis
- Mathematical aspects of data science
- Numerical analysis
- Complex fluids and soft matter

- Molecular dynamics
- Exponential asymptotics
- Uncertainty quantification
- Bayesian inverse problems





Machine Learning

- Confined friction adaptive descent for neural network training
- Compressing Tractable Generative Models
- Exploiting structured matrices in large language models
- Machine learning new numerical methods for viscoelastic fluid dynamics
- Advantages of having a brain: evolutionary algorithm for neural networks
- Symmetry-invariant Tractable Generative Models
- Adversarial attacks and the limitations of neural networks
- Efficient Bayesian adaptation of neural network topology
- Applications of neural networks to studies of ocean turbulence





Numerical models and data

- Markov Chain Monte Carlo methods in Computational Imaging
- Cause and effect in imaging data
- Randomized numerical linear algebra for linear systems, eigenvalue problems, and PDEs
- Differentiating solvers for time dependent partial differential equations using JAX
- Ocean modelling using Julia





Mathematical Biology

- Modelling the flow around the brain accounting for brain sulci
- Nonlinear waves in the brain: Industry project with Sigma Solutions
- Quantifying the contribution of DNA damage to cancer mutations
- Using machine learning techniques for remotely detecting tree death and forest disturbance
- Multiple scales in models for three-trophic-level food chains
- Disease Spread on a Hypergraph Model of Edinburgh
- Affects of ageing on accumulation of mutations in bacteria





Many other topics...

- Discrete Exterior Calculus on graphs
- Evolving Network Models: Beyond Triadic Closure
- Exponential asymptotics for integrals
- Friends of Friends
- Inferring the size of tiny droplets from impact force
- Learning to optimize
- Random graph topology and phase transition
- Stable 3-body orbits and unstable N-body choreographies





Support during your studies

Student support

- Student Advisers
- Academic Cohort Leads
- Advice on study technique
- Employability/careers guidance
- General pastoral support
- MSc community
 - MScHub dedicated study space
 - MScBase study support from tutors
 - MathSoc







Careers after CAM

- Machine Learning Engineer ABN AMRO Bank
- Software Engineer Microsoft
- Investment Analyst Abrdn
- Data Scientist Space Intelligence
- Software Engineer Esri
- Data Scientist Greene King
- PhD studies at Bristol, Edinburgh, St Andrews, Warwick, ETH, EPFL...







CAM Virtual Open Day Alumni Experience

Aidan Tully

Before CAM

• Wexford, IE



• UCD (Dublin, IE) - BSc Applied and Computational Maths

- o 4 years.
- Short research project in final year.
- Interest in courses on numerics, fluids and 'using' maths.

• Applying for MSc's

- Wanted to continue looking at these areas
- o Move abroad
- Quality of teaching & department



During CAM

- Semester 1/ Winter
 - Good mix of introductory and intermediate courses.
 - Hard work but achievable!
- Semester 2/ Spring
 - More advanced courses
 - Some build on semester 1 courses
 - e.g. Python Programming \rightarrow ML in Python
- Semester 3/ Summer
 - Dissertation project "Tracer particle statistics in turbulent flow"
 - Hands on application of work from the last 8 months.
 - Computation on University HPC cluster.



Around CAM

• Soft Skills

- o Workshops/ Careers service
- Time / workload management
- Research skills/ independent working
- Edinburgh and surrounds
 - Large town more than small city
 - Lots of nature on your doorstep
- UoE Clubs & Societies
 - o MathSoc
 - Regional societies
 - Snowsports/wakeboarding winter trip
 - Many others!
- New friends





Post-CAM

- PhD at Edinburgh
 - Directly apply a lot of MSc
 - Especially research project

- Careers Service still using today
 - Engineering / Modelling / Energy
 - o Banking/ Insurance



• Difficult but rewarding!





Type your questions into the chat area



Next steps...

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Contact details for follow-up questions

 We apologise if we did not get through all of your questions in the time allotted for this session. If you have further questions that have not been answered, please email: <u>futurestudents@ed.ac.uk</u>





Thank you – click 'Leave' when the session ends

Return to your 'e-ticket' to find and attend other sessions you've booked – by clicking on the button in the email we sent you...



- ...and visit the events hub:
- <u>https://edin.ac/4gZuP3G</u>









Thank you

Further questions? futurestudents@ed.ac.uk

