THE UNIVERSITY of EDINBURGH

Introduction to the Financial Mathematics MSc programmes

Dr Stefan Engelhardt | 13 November 2024

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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

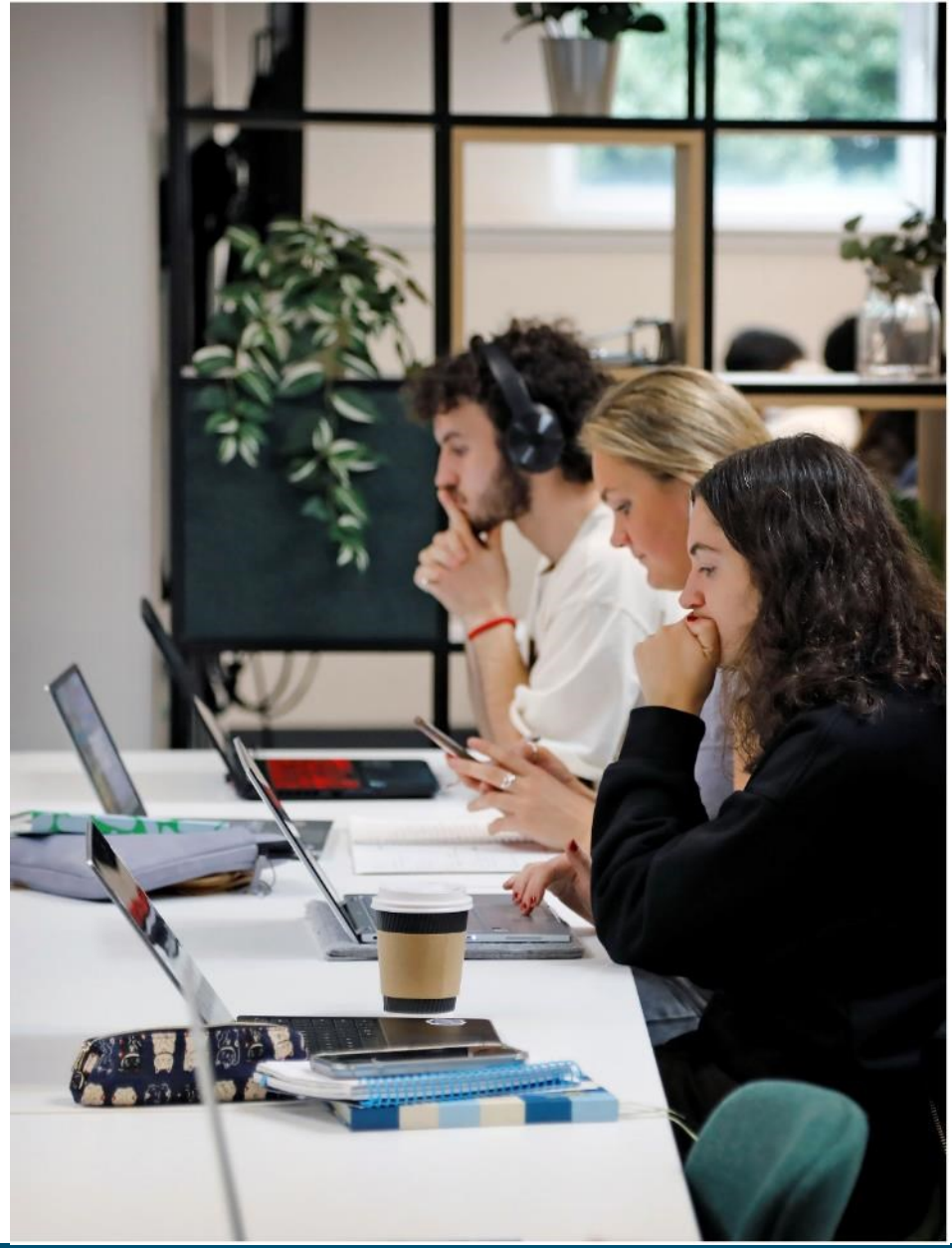
School of Mathematics

- 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 65 study a Financial Mathematics MSc.

CMF/FMO MSc: Student cohort

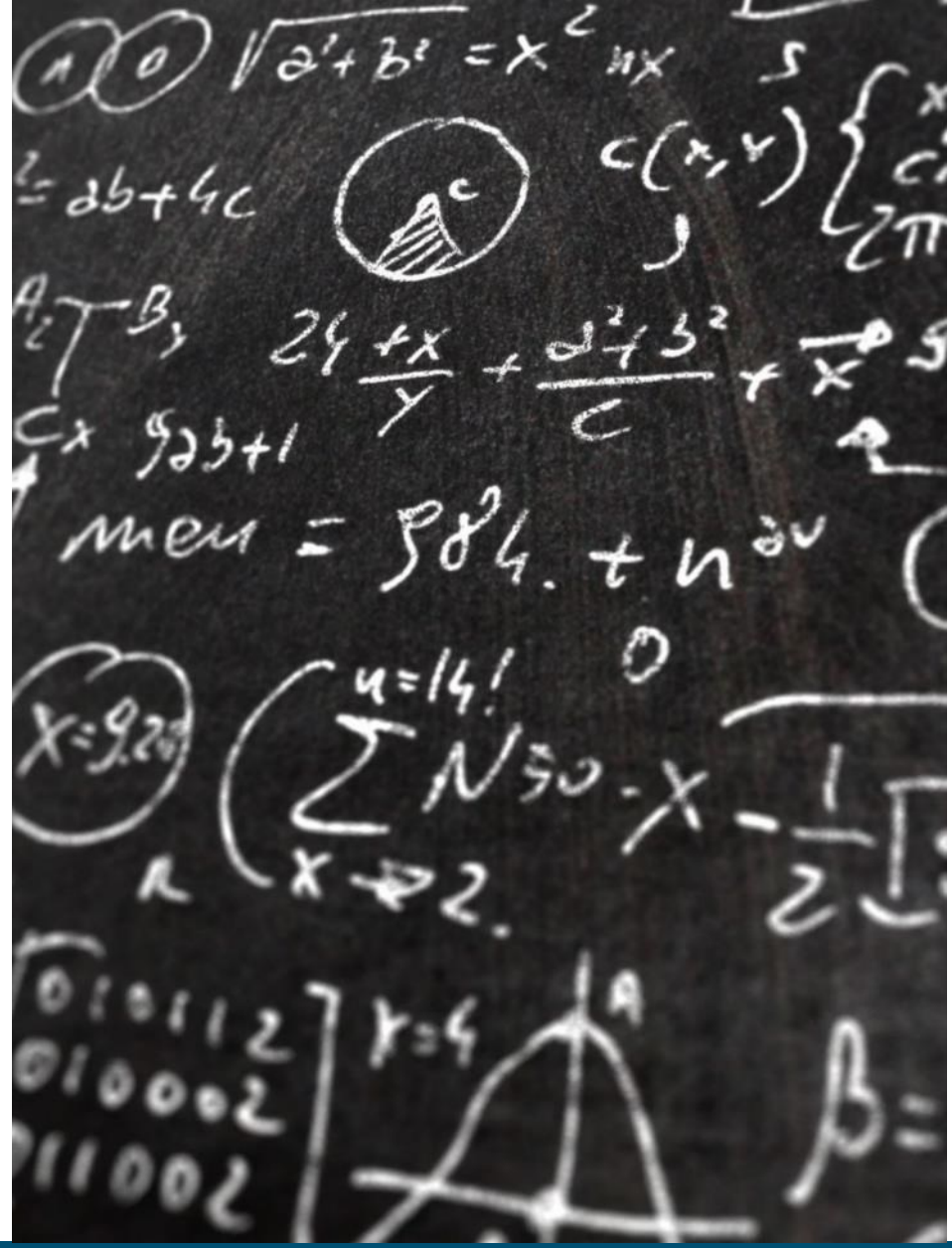
- Super cosmopolitan cohort
- Usually evenly split across both programmes
  - China
  - Denmark
  - India
  - Ireland
  - South Korea
  - Spain
  - Sweden
  - Turkey
  - United Kingdom



General framework of the MSc

- Taught component: 120 credits
  - Mix of compulsory and optional courses
  - CMF - three streams (Computational, Financial or Machine Learning)
- Dissertation (research project): 60 credits
- Duration: 12 months (full-time)

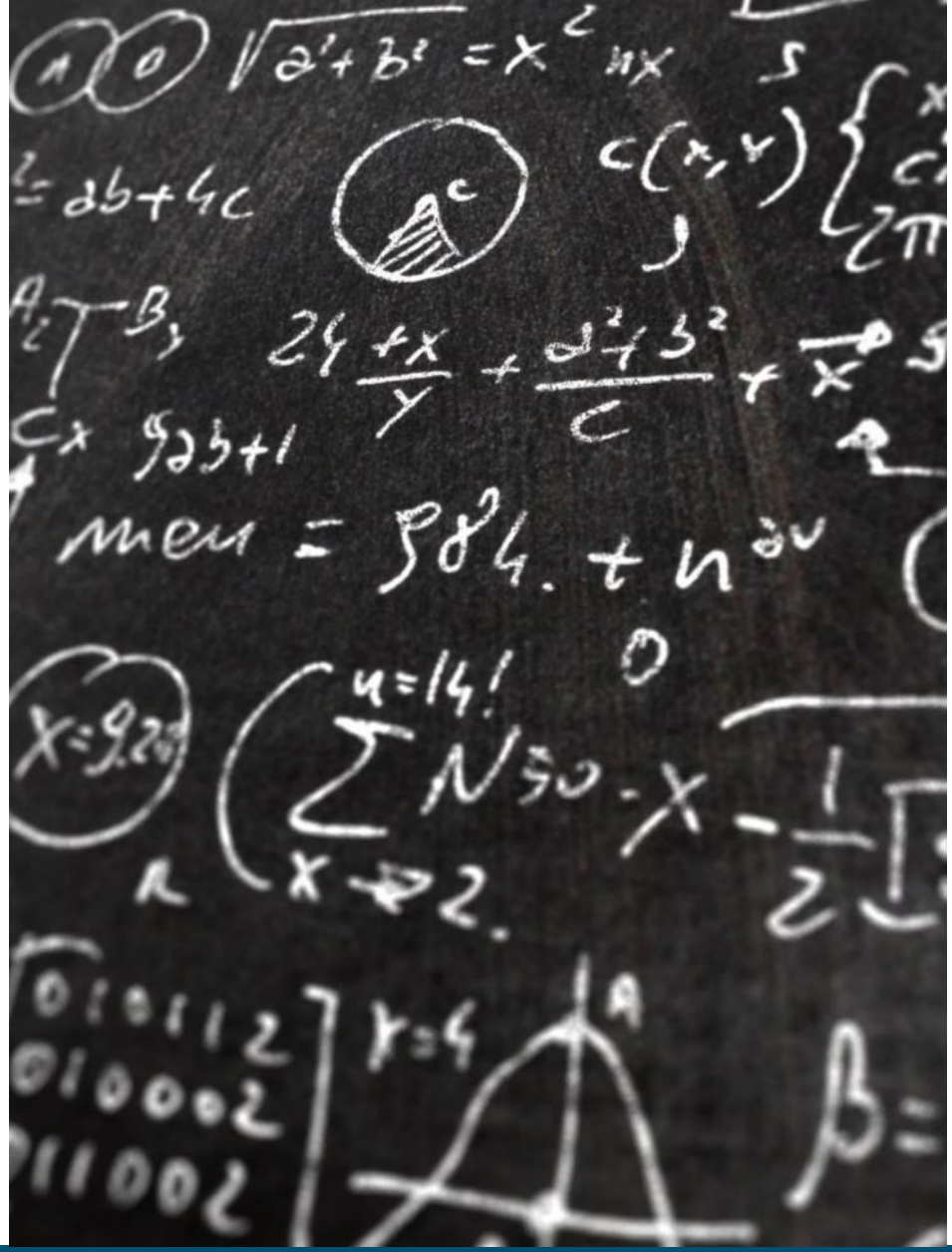
FYI: 10 credits correspond to 100 hours of work / study of which typically only about 20 are lectures and 5 are workshops.



Computational Mathematical Finance (CMF) – taught course structure

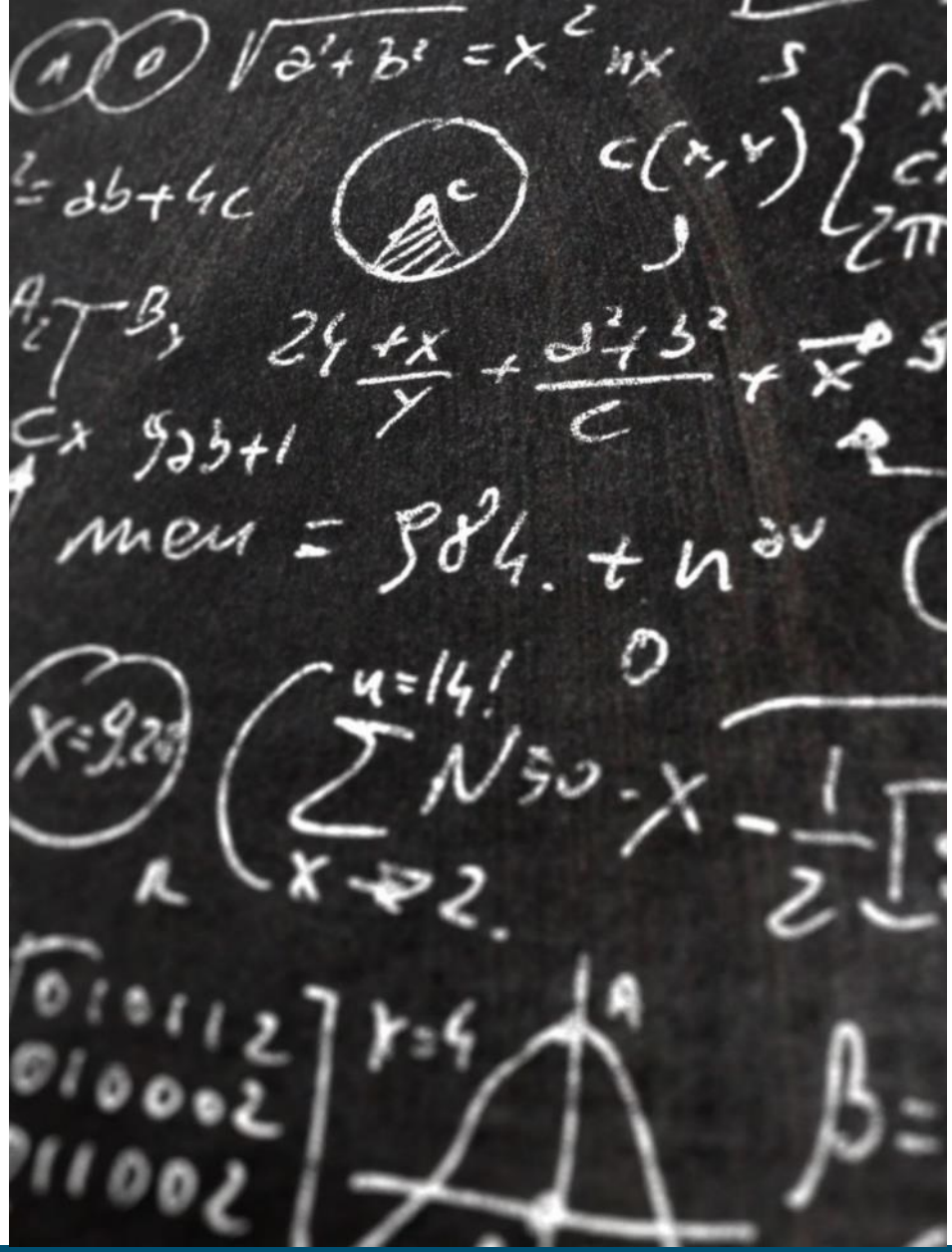
- Core courses are 80 credits.

- Further 40 credits are optional but must fit one of:
  - Computational stream,
  - Financial stream,
  - Machine Learning stream.



Financial Modelling and Optimization (FMO) – taught course structure

- Core courses are 80 credits.
- Optional courses are 40 credits.



Core courses for both CMF and FMO

- Discrete Time Finance: introduce measure theoretic probability, filtrations, martingales, stopping times and finance applications.
- Stochastic Analysis in Finance: stochastic processes in continuous time, Wiener process, Itô integral, Itô isometry and Itô formula and all tools required for Black-Scholes framework of derivative pricing.
- Risk-Neutral Asset Pricing: builds on DTF and SAF to further explore pricing and hedging in various models, arbitrage, incomplete markets and interest rate models.
- Numerical Probability and Monte Carlo: Monte Carlo method and numerical methods to find solutions to stochastic differential equations, both are key in derivative pricing and many other applications.
- Research-Skills in Financial Mathematics.

Further core courses – CMF

- **Python Programming**: Introduction to Python programming with focus on solving mathematical problems and working with data.
- **Stochastic Control and Dynamic Asset Allocation**: Bellman principle and equation, connection to *Reinforcement Learning*, Pontryagin's optimality principle and BSDE and applications: Merton asset allocation problem, Optimal order execution and more.

Computational Stream:

- **Time Series**: Moving average, Autoregressive and ARMA models, Frequency analysis, GARCH and Stochastic Volatility models, Kalman filter.
- **Numerical Partial Differential Equations**: time and space discretization, finite difference methods, finite element methods, Sobolev spaces, Lax-Milgram Lemma.

Further core courses – CMF

Financial Stream:

- **Financial Risk Theory**: Utility functions, VaR, Convex and Coherent Risk Measures, Copulas, Dimension Reduction, Factor Analysis.
- **Optimization Methods in Finance**: Mean-Variance portfolio selection, Conic Optimization, Asset/liability management, Stochastic Gradient Descent, Scenario Generation

Machine Learning Stream:

- **Machine Learning in Python**: Supervised vs. unsupervised learning, Regression vs. classification, Linear regression, Basis function expansion, Overfitting, Training, Testing, Generalisation, Cross-validation, Evaluating/comparing models, Classification, Naïve Bayes, Decision trees/random forests.

Further core courses – FMO

- Fundamentals of Optimization: Linear Programming, Simplex Method, Duality in Linear Programming, Lagrangian Relaxation . . .

- Optimization Methods in Finance: Mean-Variance portfolio selection, Conic Optimization, Asset/liability management, Stochastic Gradient Descent, Scenario Generation

Optional courses

All of the above . . . and some of the other most popular include:

- Algorithmic Game Theory and Its Applications (School of Informatics)
- Bayesian Data Analysis
- Blockchains and Distributed Ledgers (School of Informatics)
- Credit Scoring
- Finance, Risk and Uncertainty
- Machine Learning in Python,
- Optimization Methods in Finance,
- Programming Skills (School of Informatics),
- Reinforcement Learning (School of Informatics)

Research Skills for Financial Mathematics

- Worth a total of 10 credits, running in Semester 2.
- Skills component: where / how to find relevant research.
- Ethics component: working with models and data, communicating technical results to others.
- Talks by industry practitioners and researchers in maths finance.
- Guided reading on a given topic presented (book chapters, papers).
- Group project consisting of an essay and a presentation.

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		Discrete-Time Finance lecture	Finance, Risk and Uncertainty lecture		Python Programming lecture		Discrete-Time Finance workshop (every 2nd week)	Stochastic Analysis in Finance lecture	
Tuesday		Bayesian Theory lecture			Bayesian Theory workshop (every 2nd week)	Finance, Risk and Uncertainty workshop			
Wednesday				Stochastic Analysis in Finance workshop					
Thursday		Discrete-Time Finance lecture					Stochastic Analysis in Finance lecture		
Friday					Python Programming workshop				

Dissertation – Summer projects

- During the period from June to August, candidates for the MSc work on a project on an approved topic, and write a dissertation based on this work.

- Some projects are offered by industrial partners (often via the Scottish Financial Risk Academy, SFRA) that offer summer placements to MSc students who work on short research projects and write their MSc dissertations under the joint supervision of an industrial partner and a member of an academic department.
  - Industrial projects have a flexible format: student may spend whole period working at company or interact through a series of visits.
  - Industrial projects will be advertised in Semester 2 (coordinated with SFRA) and you may need to submit a CV / go through an interview.

- Academic summer project topics will be made available towards the end of Semester 2.

Academic summer projects

Past project topics offered included:

- A regularity structure for rough volatility,
- Chaos expansions for regressions and Credit valuation adjustment calculations,
- Efficient calibration of a LIBOR market model with stochastic volatility,
- Efficient Model Calibration with Machine Learning,
- Fractional Brownian motion and a stochastic volatility model,
- Levy processes in financial modelling,
- Local volatility modelling,
- Machine Learning and Rough Paths,
- Machine Learning Techniques for Path-Dependent Derivatives
- . . .

Industrial summer projects

Industrial project partners in the past included:

- **Aberdeen Standard Investments**: Systematic strategies for trade execution optimisation, . . .
- **Royal Bank of Scotland**: Machine learning techniques for stress testing, Forecasting methodologies for stress testing, . . .
- **Lloyds Banking Group**: Pro-cyclicality of Credit Risk Impairment Losses Under the IFRS9 Accounting Standard,
- **Moody's Analytics**: Bond return risk factor modelling, Vine Copulas For Stressing Correlations, Quantitative analytics of dynamic asset management, . . .
- **Hymans Robertson**: Pensions decision simulation framework, Pensions guidance data analysis, . . .
- **Scottish Widows**: AI/Machine Learning insights for actuarial models, . . .
- **Morgan Stanley**: Government Bond Risk Aggregation, . . .

After graduation

The MScs in CMF / FMO equip you with the skills needed to work in quantitative analytics or risk management roles in the financial industry or PhD study.

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

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Q&A

Type your questions into the chat area

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Next steps…

https://virtualvisits.ed.ac.uk/pg

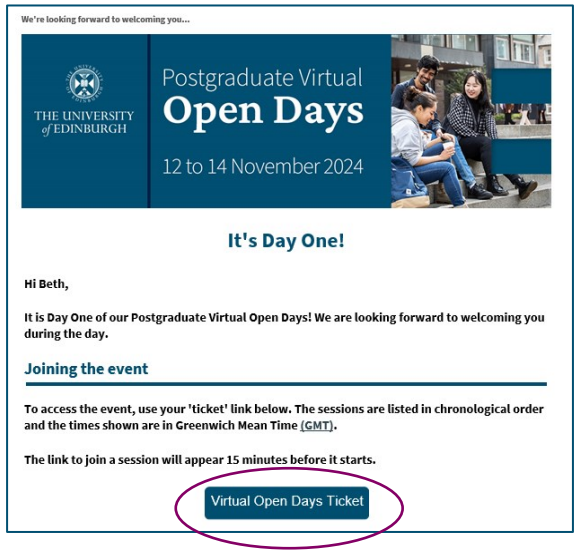
https://edin.ac/student-chat-pg

Contact details for follow-up questions

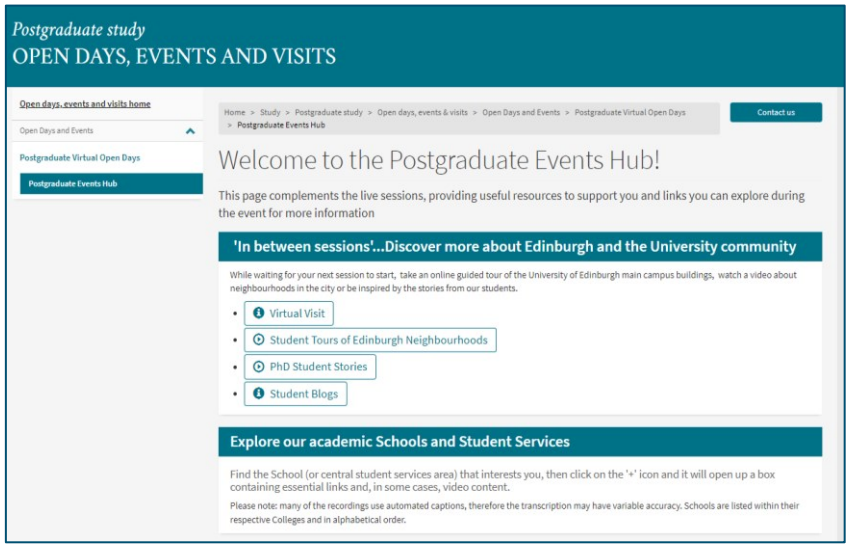
- We apologise if we did not get through all of your questions in the time allotted for this session. If you have further questions that have not been answered, please email: futurestudents@ed.ac.uk

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:
- https://edin.ac/4gZuP3G



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Thank you

Further questions?

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