BSc Mathematics, Optimisation and Statistics

This document provides a definitive record of the main features of the programme and the learning outcomes that a typical student may reasonably be expected to achieve and demonstrate if s/he takes full advantage of the learning opportunities provided. This programme specification is intended as a reference point for prospective students, current students, external examiners and academic and support staff involved in delivering the programme and enabling student development and achievement.

Programme Information				
Award(s)	BSc			
Programme Title	Royal College of Science			
Programme Code	Mathematics			
Awarding Institution	GG31			
Teaching Institution	Imperial College London			
Faculty	Imperial College London			
Department	Faculty of Natural Sciences			
Associateship	Department of Mathematics			
Mode and Period of Study	3 academic years full-time			
Cohort Entry Points	Annually in October			
Relevant QAA Benchmark Statement(s) and/or other external reference points	Mathematics, Statistics and Operational Research			
Total Credits	ECTS:	184.5 - 185.5	CATS:	369 - 371
FHEQ Level	Level 6			
EHEA Level	1st cycle			
External Accreditor(s)	Not applicable, but approved by Institute of Mathematics and its Application, Institute of Actuaries, etc.			
Specification Details				
Student cohorts covered by specification	2016/17 entry			
Person responsible for the specification	Professor David Evans, Director of Undergraduate Studies, Mathematics.			
Date of introduction of programme				

Date of programme specification/revision	August 2016

Description of Programme Contents

The programme aims to present a wide range of mathematical ideas in a way which develops students' critical and intellectual abilities. It encourages enthusiasm for the subject as a discipline that is of value both in its own right and in its applications. It aims to provide a good knowledge of a broad range of topics in mathematics and to allow students to acquire a more advanced knowledge of selected parts of the subject. Students have the opportunity to develop mathematical and communication skills that will be useful in scientific or other jobs.

Much of the programme in years 1 and 2 is core. During the final year of the programme students can choose from a large selection of modules across a very wide range of areas of Mathematics. They also have the opportunity to take a limited number of modules delivered outside the department.

Teaching of Mathematics modules takes place at the College's South Kensington Campus, usually within the Department of Mathematics. Most teaching sessions are delivered by staff from the Department of Mathematics. These are predominantly permanent faculty, but also include teaching fellows and research associates. Problem classes are supported by Graduate Teaching Assistants.

A student on this programme will have taken a substantial number of modules related to statistics and optimisation.

Learning Outcomes

The Imperial Graduate Attributes are a set of core competencies which we expect students to achieve through completion of any Imperial College degree programme. The Graduate Attributes are available at: www.imperial.ac.uk/students/academic-support/graduate-attributes

Programme Aims/Objectives:

- Provide high quality education in Mathematics within an environment committed to excellence in both teaching and research.
- Attract well-qualified students and to provide intellectual challenge in a structure containing an appropriate amount of flexibility, so that students can develop their specialist interests.
- Teach and provide the opportunities to learn a core of mathematics fundamental to the education of all mathematicians, together with a wide range of higher level options in Mathematics and allowing some broadening of study through a range of Management and Humanities options.
- Introduce students to a wide-range of applications of Mathematics.
- Equip students with a range of mathematical skills – in problem-solving, project work, computation and presentation – to enable them to take prominent roles in a wide spectrum of employment and research.
- Provide an in-depth understanding of statistics and optimisation.

Knowledge and Understanding:

- The fundamentals of Mathematics as a living discipline in its own right;
- The development of the application of Mathematics as a language in a wide range of

situations relevant to research and industry;
- The importance of precision of argument;
- Problem-solving strategies and methods;
- Basic computational skills;
- A selection of subjects which students study in greater depth, according to their interests (and degree coding) leading to current developments at the frontiers of the subject.

Intellectual Skills:

- Ability to assimilate and understand a large body of complex concepts and their inter-relationships;
- Knowledge and understanding of the role of logical mathematical argument and deductive reasoning, together with formal processes of mathematical proof and development of mathematical theories;
- Use of a structured mathematical analytical approach to problem solving, including the importance of assumptions made and consequences of their violation;
- Use of Mathematics to describe and model in applications, including appropriate solution method and interpretation of results;
- Carry out extended investigative mathematical work as an individual and as part of a small group.

Practical Skills:

- Carry out investigative project work as an individual and as part of a small group;
- Use symbolic and numerical software as part of practical computation.

Transferable Skills:

- Solve open-ended problems and problems with well-defined solutions by formulating problems in precise terms, identifying key issues and trying different approaches in order to make progress;
- Carry out an independent investigation using textbooks and other available literature, searching databases and interacting with colleagues and staff to extract important information;
- Communicate effectively by listening carefully and presenting complex information in a clear and concise manner orally, on paper and using IT;
- Use analytical skills, paying attention to detail and using technical language correctly, to manipulate precise and intricate ideas, to construct logical arguments;
- Use IT skills for communication and analysis;
- Work independently use their initiative, organize themselves to meet deadlines, plan and execute an extended project;
- Work in groups, interacting constructively with others.

Entry Requirements	
Academic Requirement	For Mathematics degrees (except joint Mathematics and Computer Science) the normal minimum entry requirement is A*A*A overall, to include: A* in Mathematics A* in Further Mathematics A in one other A-level (though not essential, strong candidates take Physics and/or Chemistry) Mathematics Admissions Test (MAT) or STEP papers
Non-academic Requirements	None
English Language Requirement	IELTS 6.5 with a minimum of 6.0 in each element or equivalent
The programme's competency standards documents can be found at: http://www.imperial.ac.uk/natural-sciences/departments/mathematics/study/students/undergraduate/programme-information/	
Learning & Teaching Strategy	
Scheduled Learning & Teaching Methods	• Lectures • Problem classes • Tutorials • Office hours
E-learning & Blended Learning Methods	• Computational work • Matlab • Python
Project and Placement Learning Methods	• Group project • Individual assignments • Problem sheets • Optional 3rd year project
Assessment Strategy	
Assessment Methods	• Written examinations • Coursework • Practical and project work
Academic Feedback Policy	
Extensive programme of Assessed Coursework/Tests – marked by GTAs and returned. Assessments and Projects – written feedback and an oral presentation.	

Re-sit Policy
The College's Policy on Re-sits is available at: www.imperial.ac.uk/registry/exams/resit
Mitigating Circumstances Policy
The College's Policy on Mitigating Circumstances is available at: www.imperial.ac.uk/registry/exams
Assessment Structure
Marking Scheme

Assessment Rules and Degree Classification:

- Within the Department the total raw mark from each course assessment is SCALED to a 'Mathematics scale mark' so that overall performances can be compared.
- Other than for courses which are assignment/project based, assessed coursework typically contributes in total to no more than 10% of each of the course raw mark totals.
- Details of assessment are contained within the overall First, Second, Third Year Course documents
- Honours marks for each year total:
  First Year 900 (=8 x 100 +50 +50) for the eight course assessments, computation and the first year individual project.
  Second Year 850 (=8 x 100 +50) for the eight course assessments and the second year group project.
  Third Year 800 (=8 x 100) for the eight course assessments, which are all optional and may include a project.
- All candidates who pass each year of their course will be considered for honours classification at final graduation.
- Within the Department final honours assessment is based on total scaled marks after the corresponding year weighting has been applied.
- A mark out of 1000 on the Mathematics scale is obtained. Automatic classification for some marks is as follows:

Automatic Class: TOTAL MARK on Mathematics scale

First Class: at least 700
Upper Second Class: 550 - 680
Lower Second Class: 440 - 530
Third Class: 300-420

Separation lines are set in collaboration with the External Examiners somewhere between the automatic bands. Candidates close to these lines are discussed individually at the Final Meeting of the Mathematics Examining Sub-Board on the basis of the full spectrum of academic performance during the programme.

It should be noted that reporting of marks for individual courses on course transcripts is carried out by translation to the common College scale on which the grades for individual courses are:-

GRADE, MARKS, INTERPRETATION

A	70% - 100% Marks represent a First Class performance
B	60% - 69% Marks represent an Upper Second Class performance
C	50% - 59% Marks represent a Lower Second Class performance
D	40% - 49% Marks represent a Third Class performance
E	0% - 39% Marks represent a Fail performance

Scaling

Due to the nature of Mathematics as an academic discipline it is often necessary for the raw marks in an assessment to be scaled in order that they map appropriately onto the British undergraduate degree classification system. In accordance with paragraph 18.4 of the Regulations for the Examination of BSc, MSci, BEng, MEng, MBBS Degrees, this process is conducted in consultation with the relevant External Examiner, applied consistently to all students in the cohort and reported at the final meeting of the Board of Examiners. Further details regarding the Department's approach to scaling may be found in the programme handbook.

Module Weightings			
Year	% Year Weighting	Module	% Module Weighting
Year One	11.1%	Mechanics	11.1%
		Foundations of Analysis	11.1%
		Geometry and Linear Algebra	11.1%
		Mathematical Methods I	11.1%
		Mathematical Methods II	11.1%
		Analysis I	11.1%
		Algebra I	11.1%
		Probability and Statistics I	11.1%
		Mathematical Computation	5.55%
		Individual Poster Project	5.55%
Year Two	33.33%	Differential Equations	11.76%
		Multivariable Calculus	11.76%
		Introduction to Numerical Analysis	11.76%
		Real Analysis	11.76%
		Algebra II	11.76%
		Complex Analysis	11.76%
		Probability and Statistics II	11.76%
		Group Project	5.88%
		1 x module from elective group (A)	11.76%
Year Three	55.6%	*8 x modules from elective groups (B/C/D/E)**	12.5% each

**Please note the following rules for year three:*

Students may select EITHER: at most 3 x modules from elective group (C) OR at most 2 x modules from elective groups (C) AND (D) combined.

Students may select NO MORE THAN 1 x module from elective group (E)

As well as the regular G100 degree, the department offers several specialist degree codings. To qualify for the BSc coding GG31, a suitable number of modules must eventually be passed from subsets of the general list as follows:

6 x modules from: M2S2, M3S1, M3S2, M3S4, M3S8, M3S9, M3S11, M3S14, M3S16, M3S17, M3P17, M3SC, M3R.

Indicative Module List												
Code	Title	Core/ Elective	Year	L&T Hours	Ind. Study Hours	Place-ment Hours	Total Hours	% Written Exam	% Course-work	% Practical	FHEQ Level	ECTS
M1A1	Mechanics	CORE	1	40	122.5	0	162.5	90%	10%	0%	4	6.5
M1C	Mathematical Computation	CORE	1	40	60	0	100	0%	100%	0%	4	4
M1F	Foundations of Analysis	CORE	1	40	122.5	0	162.5	90%	10%	0%	4	6.5
M1GLA	Geometry and Linear Algebra	CORE	1	40	122.5	0	162.5	90%	10%	0%	4	6.5
M1M1	Mathematical Methods I	CORE	1	40	122.5	0	162.5	90%	10%	0%	4	6.5
M1M2	Mathematical Methods II	CORE	1	40	122.5	0	162.5	90%	10%	0%	4	6.5
M1P1	Analysis I	CORE	1	40	122.5	0	162.5	90%	10%	0%	4	6.5
M1P2	Algebra I	CORE	1	40	122.5	0	162.5	90%	10%	0%	4	6.5
M1R	Individual Poster Project	CORE	1	16.5	96	0	112.5	0%	100%	0%	4	4.5
M1S	Probability and Statistics I	CORE	1	40	122.5	0	162.5	90%	10%	0%	4	6.5
M2AA1	Differential Equations	CORE	2	40	135	0	175	90%	10%	0%	5	7
M2AA2	Multivariable Calculus	CORE	2	40	135	0	175	90%	10%	0%	5	7
M2AA3	Introduction to Numerical Analysis	CORE	2	40	135	0	175	90%	10%	0%	5	7
M2PM1	Real Analysis	CORE	2	40	135	0	175	90%	10%	0%	5	7

Indicative Module List												
Code	Title	Core/ Elective	Year	L&T Hours	Ind. Study Hours	Place-ment Hours	Total Hours	% Written Exam	% Course-work	% Practical	FHEQ Level	ECTS
M2PM2	Algebra II	CORE	2	40	135	0	175	90%	10%	0%	5	7
M2PM3	Complex Analysis	CORE	2	40	135	0	175	90%	10%	0%	5	7
M2R	Group Project	CORE	2	5	120	0	125	0%	100%	0%	5	5
M2S1	Probability and Statistics II	CORE	2	40	135	0	175	90%	10%	0%	5	7
M2AM	Non-linear Waves	ELECTIVE (A)	2	40	135	0	175	90%	10%	0%	5	7
M2PM5	Metric Spaces and Topology	ELECTIVE (A)	2	40	135	0	175	90%	10%	0%	5	7
M2S2	Statistical Modelling I	ELECTIVE (A)	2	40	135	0	175	90%	10%	0%	5	7
M3A2	Fluid Dynamics I	ELECTIVE (B)	3	30	170	0	200	100%	0%	0%	6	8
M3A4	Mathematical Physics I: Quantum Mechanics	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3A6	Special Relativity and Electromagnetism	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3A7	Tensor Calculus and General Relativity	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3A10	Fluid Dynamics II	ELECTIVE (B)	3	30	170	0	200	100%	0%	0%	6	8
M3PA16	Geometric Mechanics	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3A49	Mathematical Biology	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8

Indicative Module List												
Code	Title	Core/ Elective	Year	L&T Hours	Ind. Study Hours	Place-ment Hours	Total Hours	% Written Exam	% Course-work	% Practical	FHEQ Level	ECTS
M3PA50	Introduction to Riemann surfaces and conformal dynamics	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3F22	Mathematical Finance: An Introduction to Option Pricing	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3A28	Introduction to Geophysical Fluid Dynamics	ELECTIVE (B)	3	30	170	0	200	100%	0%	0%	6	8
M3A29	Theory of Complex Systems	ELECTIVE (B)	3	30	170	0	200	0%	100%	0%	6	8
M3PA34	Dynamics, symmetry and Integrability	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3M3	Introduction to Partial Differential Equations	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3M6	Methods of Mathematical Physics	ELECTIVE (B)	3	30	170	0	200	100%	0%	0%	6	8
M3M7	Asymptotic Analysis	ELECTIVE (B)	3	30	170	0	200	100%	0%	0%	6	8
M3M9	Applied Functional Analysis	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3N4	Computational Linear Algebra	ELECTIVE (B)	3	30	170	0	200	0%	100%	0%	6	8
M3N7	Numerical Solution of Ordinary Differential Equations	ELECTIVE (B)	3	30	170	0	200	0%	100%	0%	6	8
M3N10	Computational Partial Differential	ELECTIVE (B)	3	30	170	0	200	0%	100%	0%	6	8

Indicative Module List												
Code	Title	Core/ Elective	Year	L&T Hours	Ind. Study Hours	Place-ment Hours	Total Hours	% Written Exam	% Course-work	% Practical	FHEQ Level	ECTS
	Equations I											
M3P5	Geometry of Curves and Surfaces	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3P6	Probability Theory	ELECTIVE (B)	3	30	170	0	200	100%	0%	0%	6	8
M3P7	Functional Analysis	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3P8	Algebra III	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3P10	Group Theory	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3P11	Galois Theory	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3P12	Group Representation Theory	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3P14	Number Theory	ELECTIVE (B)	3	30	170	0	200	100%	0%	0%	6	8
M3P15	Algebraic Number Theory	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3P17	Algebraic Combinatorics	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3P18	Fourier Analysis and Theory of Distributions	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3P19	Measure and Integration	ELECTIVE (B)	3	30	170	0	200	100%	0%	0%	6	8
M3P20	Geometry I: Algebraic Curves	ELECTIVE (B)	3	30	170	0	200	100%	0%	0%	6	8

Indicative Module List												
Code	Title	Core/ Elective	Year	L&T Hours	Ind. Study Hours	Place-ment Hours	Total Hours	% Written Exam	% Course-work	% Practical	FHEQ Level	ECTS
M3P21	Geometry II: Algebraic Topology	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3P60	Geometric Complex Analysis	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3PA23	Dynamical Systems	ELECTIVE (B)	3	30	170	0	200	100%	0%	0%	6	8
M3PA24	Bifurcation Theory	ELECTIVE (B)	3	30	170	0	200	100%	0%	0%	6	8
M3PA48	Dynamics of Games	ELECTIVE (B)	3	30	170	0	200	0%	100%	0%	6	8
M3R	Research Project in Mathematics	ELECTIVE (B)	3	0	200	0	200	0%	100%	0%	6	8
M3S1	Statistical Theory I	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3S2	Statistical Modelling II	ELECTIVE (B)	3	30	170	0	200	75%	25%	0%	6	8
M3S4	Applied Probability	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3S8	Time Series	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3S9	Stochastic Simulation	ELECTIVE (B)	3	30	170	0	200	75%	25%	0%	6	8
M3S11	Games, Risks and Decisions	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3S14	Survival Models and Actuarial Applications	ELECTIVE (B)	3	30	170	0	200	90%	10%	0%	6	8
M3S16	Credit Scoring I	ELECTIVE (B)	3	30	170	0	200	75%	25%	0%	6	8

Indicative Module List												
Code	Title	Core/ Elective	Year	L&T Hours	Ind. Study Hours	Place-ment Hours	Total Hours	% Written Exam	% Course-work	% Practical	FHEQ Level	ECTS
M3S17	Quantitative Methods in Retail Finance	ELECTIVE (B)	3	30	170	0	200	75%	25%	0%	6	8
M3SC	Scientific Computation	ELECTIVE (B)	3	30	170	0	200	0%	100%	0%	6	8
M3E	Econometric Theory and Methods	ELECTIVE (C)	3	30	170	0	200	90%	10%	0%	6	8
M3H	History of Mathematics	ELECTIVE (C)	3	30	170	0	200	100%	0%	0%	6	8
M3T	Communicating Mathematics	ELECTIVE (C)	3	12	153	35	200	0%	100%	0%	6	8
M3B	Mathematics of Business & Economics	ELECTIVE (C)	3	30	170	0	200	90%	10%	0%	6	8
M3C	Introduction to High Performance Computing	ELECTIVE (C)	3	30	170	0	200	0%	100%	0%	6	8
N/A	Horizons**	ELECTIVE (D)	3	Various			150	Various				6
N/A	Business for Professional Engineers & Scientists**	ELECTIVE (D)	3	Various			150	Various				6
M2AM	Non-linear Waves	ELECTIVE (E)	3	40	135	0	175	90%	10%	0%	5	7
M2PM5	Metric Spaces and Topology	ELECTIVE (E)	3	40	135	0	175	90%	10%	0%	5	7
M2S2	Statistical Modelling I	ELECTIVE (E)	3	40	135	0	175	90%	10%	0%	5	7

**Students may only take certain Horizons and Business for Professional Engineers & Scientists modules approved by the department for credit. Please contact your Director of Undergraduate Studies (DUGS) for information on which modules are available to you.

Supporting Information
The Programme Handbook is available at: http://www.imperial.ac.uk/natural-sciences/departments/mathematics/study/students/undergraduate/programme-information/
The Module Handbook is available at: http://www.imperial.ac.uk/natural-sciences/departments/mathematics/study/students/undergraduate/programme-information/
The College's entry requirements for undergraduate programmes can be found at: www.imperial.ac.uk/study/ug/apply/requirements/
The College's Quality & Enhancement Framework is available at: www.imperial.ac.uk/registry/proceduresandregulations/qualityassurance
The College's Academic and Examination Regulations can be found at: http://www3.imperial.ac.uk/registry/proceduresandregulations/regulations
Imperial College is an independent corporation whose legal status derives from a Royal Charter granted under Letters Patent in 1907. In 2007 a Supplemental Charter and Statutes was granted by HM Queen Elizabeth II. This Supplemental Charter, which came into force on the date of the College's Centenary, 8th July 2007, established the College as a University with the name and style of "The Imperial College of Science, Technology and Medicine". http://www.imperial.ac.uk/admin-services/secretariat/college-governance/charters-statutes-ordinances-and-regulations/
Imperial College London is regulated by the Higher Education Funding Council for England (HEFCE) http://www.hefce.ac.uk/reg/of/