Unit Selection in Year 1 for SAMBa 2.0 (2019/20)

This document is intended to help you select a programme of study for the first year of your SAMBa PhD. As you are probably already aware, the first year of study is a taught programme, and you will spend most of your time taking units which will be assessed in a variety of ways. The taught part of the year is split into two 11 week semesters, with an exam period at the end of each one, and a summer period.

We want to emphasise that as well as studying, we also expect you to be making the transition to an active member of the SAMBa family, that means taking part in many of the other activities expected of SAMBa students (including SAMBa conference, away days, ITTs, cohort activities and more), and generally getting involved in opportunities within the department. You will also need to be thinking about the direction of your eventual PhD project, and this will mean discussing ideas with potential academic supervisors, as well as attending research seminars or reading courses in these areas.

During the first two semesters you will take some compulsory and optional units, which will equate to a total of 60 credits. Over the summer (as long as you have passed the taught units with an average of at least 60%), you will embark on a **Thesis Formulation Report**, and at this stage you will be expected to have identified the supervisory team for your PhD.

Failure to pass the first year programme will mean that you are unable to progress onto the research phase of the PhD. Successful completion of the first year will lead to the award of an MRes degree.

Compulsory Units

In your first year of study, you will need to take 60 credits worth of units across semesters one and two. Of these, 24 credits are compulsory, corresponding to the units:

- **Student-led symposia and integrative think tanks (MA50246), 12 credits**: this unit consists of a wide range of activities, including presentations, student-led training and events, and preparation and realisation of the integrative think tanks (ITTs), which take place in January and June.
- **Inter-disciplinary research projects (MA50264), 12 credits**: this unit will involve conducting an all-year research project led by an academic staff member as a group of students. You will be allocated a role in a team at the start of each semester, with outcomes relating to the overall research goals of the project. At the end of each semester, you will be required to present your research outcomes.

Both units run across semesters one and two.

Optional Units

The remaining 36 credits are to be chosen from a wide range of different possibilities. All potential units are worth 6 credits each, so this corresponds to a further 6 units. You should discuss your unit choice with your co-factor, and your final programme must be agreed with your Director of Studies (this meeting will happen in the first week of your study). However, there are two important criteria that you must meet:

- You need to take a program which provides breadth across the full range of Statistical Applied Mathematics. In particular, you must take two units from each of the three subject areas:

    - **Statistics and Data Science**
    - **Applied and Probabilistic Analysis and Modelling**
    - **Computation and Numerical Mathematics**

  Which units fall in which category is listed below.
- You must take four *core* SAMBa units. These are units that most completely reflect the SAMBa ideals of deep interaction between different disciplines within Mathematics. The *core* SAMBa units are:
    - Applied statistical inference (MA40198, Semester 1)
    - Applied numerical computation (MA50174, Semester 1)
    - Numerical linear algebra (MA50178, Semester 1)
    - Mathematics of machine learning (MA50263, Semester 1)
    - Numerical Solution of Elliptic PDEs (MA50170, Semester 2)
    - Inverse problems, data assimilation and filtering (MA50250, Semester 2)
    - Applied stochastic differential equations (MA50251, Semester 2)
    - Scientific computing (MA40177, Semester 2)
    - Bayesian and large scale methods (MA50247, Semester 2)

In addition to the courses listed below, you are strongly encouraged to consider taking specialist reading courses (MA50183, MA50215). These are opportunities for you to work closely with an individual member of academic staff on a topic of mutual interest. You should receive a list of suggested titles before the start of the year, but in addition, you can tailor a project more closely to your interests if you can persuade an academic to do this. You should only take units which do not cover material which you have previously seen. If you are unsure whether this is the case, please discuss with the Director of Studies.

Please send your proposed unit choices to samba@bath.ac.uk by 2nd September. These will be reviewed by the SAMBa Executive Team and you will be given the opportunity to discuss your tailored programme further with members of the team and the Director of Studies during welcome week.

Units in Statistics and Data Science:

Code	Name	Semester
MA40198	*Applied statistical inference*	S1
MA50263	*Mathematics of machine learning*	S1
MA40092	Classical statistical inference	S1
MA50084	Generalised linear models	S1
MA50087	Optimisation methods of operational research	S1
MA50247	*Bayesian and large scale methods*	S2
MA40090	Multivariate data analysis	S2
MA50085	Time series	S2
MA40189	Topics in Bayesian statistics	S2

Units in Applied and Probabilistic Analysis and Modelling

Code	Name	Semester
MA50174	*Applied numerical computation*	S1
MA50250	*Inverse problems, data assimilation and filtering*	S2
MA50251	*Applied stochastic differential equations*	S2

MA50125	Markov processes and applications	S1
MA40045	Dynamical systems	S1
MA40042	Measure theory & integration	S1
MA40254	Differential and geometric analysis	S1
MA50046	Linear control theory	S1
MA50179	Mathematical biology 1	S1
MA50181	Mathematical methods 1	S1
MA40058	Probability with martingales	S2
MA40239	Discrete probability	S2
MA50089	Stochastic processes and finance	S2
MA40048	Analytical & geometrical theory of differential equations	S2
MA40049	Elasticity	S2
MA40057	Functional analysis*	S2
MA40256	Analysis in Hilbert spaces*	S2
MA50059	Mathematical methods 2	S2
MA40203	Theory of partial differential equations	S2
MA40255	Viscous fluid dynamics	S2
MA50061	Optimal control	S2
MA50063	Mathematical biology 2	S2
PH40073	Mathematical physics	S2
PH40084	Advanced quantum theory	S2

Units in Computation and Numerical Mathematics

Code	**Name**	**Semester**
MA50178	*Numerical linear algebra*	S1
MA40177	*Scientific computing*	S2
MA50170	*Numerical solution of elliptic PDEs*	S2
MA40171	Numerical solution of evolutionary equations	S1
MA50257	Methods for stochastic systems	S1
MA40050	Numerical optimisation and large-scale systems	S2

Where online descriptions are not available for the 19/20 academic year, those for 18/19 are linked and we do not expect these descriptions to change significantly. Those without links are new units which do not have online descriptions yet. These unpublished unit descriptions are copied below.

*Functional analysis and Analysis in Hilbert spaces run in alternate years.

Inter-disciplinary research projects (MA50264)

Credits	12
Level	FHEQ level 7
Total study hours	240
Aims	To plan and deliver an extended research project, in collaboration with other team members, working across different disciplines within the general remit of Statistical Applied Mathematics.
Learning Outcomes	On successful completion of this unit the student will be able to: - Plan and deliver a research project, both individually and as part of a team.

	- Engage in the process of research, setting short-term and long-term research goals, and working towards a specific research outcome. - Anticipate difficulties in a research plan, and flexibly reassess research goals in the light of further understanding. - Demonstrate academic writing skills, code development or literature research skills, as appropriate to the research topic. - Summarise research outcomes in a group presentation. - Deliver a written report which demonstrates academic writing skills, including referencing and the appropriate use of graphs, diagrams and tables.
Skills	Carrying out independent research under guidance from an academic supervisor (T, F, A), Problem solving skills (T, F, A), Report writing (T, F, A), Group work, (F, A), Presentation skills (F, A), Time management (F, A).
Content	The scope of each project will be set out by the project supervisor(s) at the start of the course, and defined in a project description. The scope will include short and long term goals, which may evolve over the course of the project. Each project is expected to incorporate a variety of methods and content from across the spectrum of the Statistical Applied Mathematics remit, and apply knowledge from related courses.

Mathematics of machine learning (MA50263)

Credits	6
Level	FHEQ level 7
Total study hours	120
Aims	To teach Machine Learning, including theoretical background and tools for implementation, to statistical applied mathematicians.
Learning Outcomes	After taking this unit, students should be able to: - Demonstrate knowledge of modern machine learning techniques. - Use computational tools for applying machine learning. - Show awareness of the applications of these methods. - Understand the mathematical models underlying machine learning algorithms and details of their implementation. - Write the relevant mathematical arguments in a precise and lucid fashion.
Skills	Problem Solving (T,F&A), Computing (T,F&A), independent study and report writing
Content	Introduction to machine learning (supervised vs unsupervised learning, generative vs discriminative models, validation, regression vs neural networks, computational tools in Python). Additional topics will be chosen from: - Neural networks (feed-forward, convolution, recurrent networks). - Universal approximation theorem. Gradient descent - Graphical models (decision trees, random forests, Markov random fields, Boltzmann machines) - Bayesian non-parametric (Gaussian and Dirichlet process regression, hyper parameters) - Reinforcement learning - Shrinkage methods