SMSTC Prospectus 2025-26

Welcome to the Scottish Mathematical Sciences Training Centre. This document gives a brief overview for students and their supervisors of what SMSTC offers. We hope that it will be useful to you in planning the first few months of your PhD – and beyond!

SMSTC modules fall into two categories. **Core modules** are offered every year, and are formally assessed. **Supplementary modules** may change from year to year, and they may or may not be assessed. Supplementary modules are not necessarily more advanced than core modules, but often deal with a special topic of current research interest. All SMSTC students are welcome to attend both core and supplementary modules.

What we offer is designed to be flexible. SMSTC allows students to enrol in as many or as few modules as they like, in the first year or in later years of their PhDs; and to enrol in any module without taking the assessments. (However, many departments do have more specific requirements, so students are advised to discuss their choice of modules with their supervisors.) Students often gain most from taking a mixture of modules that relate directly to their research interests and modules that will **broaden their mathematical knowledge** in other areas – the latter may be more challenging, but also rewarding!

How, what, and when

SMSTC lectures are delivered by **video conference using Zoom**; departments provide local tutorial support, which is not co-ordinated by SMSTC. Lecture notes and other material may be found on our **website**, www.smstc.ac.uk . To access this material, students will need to **register** with SMSTC and then **enrol** for each module; instructions can be found on the front page of the site.

The SMSTC year begins with the **opening symposium**, which will be held on 30th September – 1st October 2025 in Perth. The symposium will include overviews of the modules, as well as sessions dealing with practical topics (such as how to get a PhD) and opportunities to meet your fellow students. We intend to follow this with further professional development events for PhD students later in the year, please look out for further details.

Semester 1: Monday 6th October to Thursday 11th December 2025
Semester 2: Monday 12th January to Thursday 19th March 2026

Each core module will be assessed by one or more **assignments**. The deadline for the final assignment is typically two or three weeks after the end of the semester, and we aim to return grades a few weeks after that. Letters will be issued to students in late May confirming the modules that they have taken and the grades they have received.

More information about the structure of SMSTC and the **content of the modules** is available on the website. Please see especially the SMSTC Information for Students page:

https://www.smstc.ac.uk/information/students

Modules available in 2025-26

Core modules

The sixteen core modules are organised on four themes: Analysis [ANA]; Applications of Mathematics [AOM]; Probability and Statistics [PAS]; Structure and Symmetry [SAS]. Lectures take place in the afternoons, Monday to Thursday, throughout each semester (see the timetable on the SMSTC website https://smstc.ac.uk/timetable). The titles of the core modules and their themes are as follows:

Semester 1

Algebraic Geometry [SAS]
Asymptotic and Analytical Methods [AOM]
Continuum Mechanics [AOM]
Differential Topology [SAS]
Dynamical Systems and Conservation Laws [ANA]
Foundations of Probability [PAS]
Measure and Integration [ANA]
Regression and Simulation Methods [PAS]

Semester 2

Algebraic Topology [SAS]
Elliptic and Parabolic PDEs [ANA]
Functional Analysis [ANA]
Mathematical Biology and Physiology [AOM]
Modern Regression and Bayesian Methods [PAS]
Numerical Methods [AOM]
Representation Theory [SAS]
Stochastic Processes [PAS]

Supplementary modules

In 2025-26 we will offer a selection of supplementary modules. Lectures take place in the mornings, Monday to Thursday, throughout each semester. Some modules may not use the full ten weeks and details will be communicated to you by the module leader.

Note that supplementary modules are not necessarily assessed, so if you need to take a module for credit then you should check the module page (and ask the lecturer if necessary).

Semester 1

Conformal Field Theory and Vertex Operator Algebras
D-modules
Homotopy Theory

Semester 2

Geometry of Elliptic Curves
Introduction to Geometric Group Theory
Resurgence
Travelling Waves in Parabolic PDEs
Gravity
Low-dimensional Topology
Stable Homotopy Theory

Last updated 10/09/25

Which modules are suitable for me?

Every student taking SMSTC will have a different academic background and interests, so modules are not labelled as “introductory” or “advanced”. The following list of expected prior knowledge should give you an idea of where each module starts relative to what you've already studied.
Before making any choices, though, you should also look at the syllabus (see the module page on the website) and, if possible, attend the Symposium where you will be able to speak with the module leader or theme head.

Core modules: expected prior knowledge

Algebraic Geometry. The notion of a module and related concepts; basics on Noetherian and Artinian modules; some commutative algebra, in particular the notion of a principal ideal domain.

Algebraic Topology. A working knowledge of metric and topological spaces; linear algebra (vector spaces, linear maps and quotient vector spaces); group theory (groups and group actions).

Asymptotic and Analytical Methods. Basic ODEs (first-order separable and first- and second-order linear equations); single- and multivariable calculus; Taylor’s theorem; linear algebra; contour integration including Cauchy's theorem.

Continuum Mechanics. Introductory courses on ODEs, PDEs, vector calculus and basic linear algebra.

Differential Topology. Multivariable calculus, Point-Set Topology, and a standard first course in Differential Geometry, for example on curves and surfaces. We recommend other interested students to get in touch with the lecturer(s). Having taken the SMSTC Algebraic Topology course, or an equivalent, is recommended. Some familiarity with Lie groups and Lie algebras would be useful, but is not essential.

Dynamical Systems and Conservation Laws. Undergraduate-level ODEs, single- and multivariable real analysis, and linear algebra.

Elliptic and Parabolic PDEs. Undergraduate-level ODEs, single- and multivariable real analysis, and linear algebra.

Foundations of Probability. Elements of mathematical analysis, linear algebra and combinatorics at undergraduate level.

Functional Analysis. Undergraduate analysis: sequences, series, pointwise and uniform convergence. Metric space topology: at least in R^d, continuity of functions, open, closed and compact sets. Countable sets. Some of the examples draw upon the measure theory from “Measure and Integration”.

Mathematical Biology and Physiology. Undergraduate-level knowledge of ODEs, PDEs, vector calculus and basic linear algebra.

Measure and Integration. Undergraduate analysis: sequences, series, pointwise and uniform convergence. Metric space topology: at least in R^d, continuity of functions, open, closed and compact sets. Countable sets.

Modern Regression and Bayesian Methods. SMSTC “Regression and Simulation Methods” or equivalent.

Numerical Methods. Basic ODEs (in particular first order separable and first- and second-order linear equations); single- and multivariable calculus; Taylor’s theorem; and linear algebra. This

module involves coding; prior knowledge of Matlab or Octave would be helpful, and students who do not have prior experience of a programming language should be aware that they will need to learn one.

Regression and Simulation Methods. Basic concepts in: probability (elementary probability distributions); statistics (ideas of estimation, confidence intervals, hypothesis tests); calculus. The level required in these areas would usually be provided in a first undergraduate course.

Representation Theory. Basic linear algebra; definitions and examples of groups, rings, fields; basic algebra concepts such as homomorphisms; basic notions of group theory – permutations, symmetric groups, Lagrange's theorem, normal subgroups and factor groups.

Stochastic Processes. Elements of mathematical analysis, linear algebra and combinatorics at undergraduate level. Probability theory, either at undergraduate level or from SMSTC “Foundations of Probability”.

Supplementary modules: expected prior knowledge

Conformal Field Theory and Vertex Operator Algebras. The module does not assume any prior knowledge of quantum field theory and can serve as an introduction into the topic for mathematicians. The main prerequisite for the module is basic knowledge of Quantum Mechanics although the essential concepts will be reminded along the way. Some basic knowledge of groups, differential geometry, functional and complex analysis is also assumed.

D-modules. Beyond basic concepts in algebra, such as "ring" and "module, or representation" we will also assume some basic knowledge of sheaves (of quasi-coherent O-modules) and derived categories. No prior knowledge is assumed in topology beyond the definition of the fundamental group of a complex manifold.

Geometry of Elliptic Curves.TBC

Gravity. For this module some basic knowledge of linear algebra, ODEs and PDEs is needed. It would be good if the students have some prior exposure to the study of curved space-times, different choices of coordinate systems, connections and curvature tensors. However, these concepts will be revised briefly at the beginning of the module. For the second part of the module some basic knowledge of quantum mechanics would be useful.

Homotopy Theory. This will begin at a level that assumes no more than the end of a standard algebraic topology course on homology and cohomology, so that it is accessible to PhD students working in any area of pure mathematics.

Specific prerequisites consist of point-set topology, group theory, and material equivalent to the SMSTC core Algebraic Topology module, or a similar master's level algebraic topology course. Some exposure to commutative algebra will be useful.

Introduction to Geometric Group Theory. This module is aimed at a wide audience in algebra, geometry, topology and mathematical physics. It will be accessible to anyone having taken a standard abstract algebra course at undergraduate level or the SMSTC "Groups, rings, fields".
A familiarity with Algebraic Topology or Differential Geometry (as in the SMSTC "Algebraic Topology" and "Manifolds") is not required but students with this background will be able to study additional examples connecting to their own research.

Low-dimensional Topology. Point set topology and the content of the first half of SMSTC Differential Topology module (e.g., definition of manifold). Knowing fundamental groups would be helpful but not strictly needed, so taking Algebraic Topology at the same time is recommended.

Resurgence. Undergraduate analysis and linear algebra, very good knowledge of Complex Analysis. An exposure to ideas of quantum mechanics and quantum field theory is helpful but not necessary.

Stable Homotopy Theory. The prerequisites for this module will be knowledge equivalent to the material of the Semester 1 module, Homotopy Theory (plus its prerequisites).

Travelling Waves in Parabolic PDEs. A good background in ODEs (e.g. the 1st part of the Dynamical Systems and Conservation Lawas SMSTC course), some linear algebra and advanced calculus.

Two relevant books are K.-P. Hadeler, Topics in Mathematical Biology, Springer, Berlin 2017, and B. H. Gilding and R. Kersner, Travelling Waves in Nonlinear Diffusion-Convection Reaction, Springer 2004.