DEPARTMENT OF MATHEMATICS
FOURTH YEAR COURSES 2021/2022

Brief Descriptions

Please note that these courses run subject to demand and we might have to ask you to make an alternative selection at the start of the semester if the class is too small.

APPLIED MATHEMATICS C, F10AC1 (Thermodynamics & Statistical Mechanics)
[Semester 1]

This course teaches the fundamental concepts of thermodynamics and statistical mechanics and describes applications to the real world. Topics covered include temperature, work, energy, heat, entropy, the four laws of thermodynamics, thermodynamic potentials, Maxwell's relations, applications to ideal gases and thermal radiation, the fundamentals of statistical mechanics, statistical entropy and equilibrium distributions.

MATHEMATICAL BIOLOGY A, F10AM1
[Semester 1]

The course aims to teach the application of ordinary differential equations and difference equations to problems in ecology. It will provide an understanding of the mathematical modelling methods that describe population dynamics, epidemiological (infectious disease) processes and evolutionary processes in ecological systems and instruction in the biological interpretation of mathematical results.

FUNCTIONAL ANALYSIS, F10MF1
[Semester 1]

This course introduces measure theory and functional analysis. The course includes measure and integration, monotone and dominated convergence theorems, application to evaluation of integrals, normed and inner product spaces, operators and their adjoints and inverses.

OPTIMIZATION, F10MM1
[Semester 1]

The main aim of this course is to present different methods of solving optimization problems in the three areas of linear programming, nonlinear programming, and classical calculus of variations. The course includes analytic techniques for analyzing functions, strong and classical Lagrangian classical techniques, linear programming and dynamic programming.

NUMERICAL ANALYSIS C, F10NC1
[Semester 1]

Ordinary differential equations (ODEs) are central to mathematics and a multitude of different applications. In almost all cases, solutions to ODEs can only be approximated and usually this is done using methods from numerical analysis on a computer. This module provides an introduction to the derivation and analysis of techniques to do this both accurately and efficiently. The course includes the derivation and analysis of the properties of single-step and multi-step approximation methods for ODE initial value problems.

PURE MATHEMATICS C, F10PC1(Topology)
[Semester 1]

Topology studies properties of mathematical objects that are unchanged under continuous transformations. The foundations of the subject begin with a framework in which continuity can be generally defined, but this course will focus on applications of topological ideas in particular settings. Topological properties include: connectedness of a network; whether you are living in a 3-dimensional or a 2-dimensional space; the interlacing properties of a knotted pattern. The course is motivated by these ideas and will study: the topology of finite graphs, and some algebraic applications; the classification of all the 2-dimensional spaces; and the mathematical theory of knots.

MATHEMATICAL BIOLOGY B, F10AN2
[Semester 2]
This course develops models of biological, medical and physiological processes including wound healing, cancer growth, heart disease, nerve impulses and disease spread. This course will teach the application of ordinary differential equations to simple biological and medical problems, the use of mathematical modelling in biochemical reactions, the application of partial differential equations in describing spatial processes such as cancer growth and pattern formation in embryonic development, and the use of delay-differential equations in physiological processes.

PARTIAL DIFFERENTIAL EQUATIONS, F10MP2
[Semester 2]
The course aims to provide knowledge in the theory of partial differential equations. The course includes classification of linear second order equations, Cauchy problems, well posed problems for PDEs, the wave equation, the heat equation, Laplace's equation and Green's functions.

NUMERICAL ANALYSIS D, F10ND2
[Semester 2]
PDEs are used as the basis for modelling many phenomena. In almost all real-world cases exact formulae for solutions to PDEs cannot be found, and approximations are used instead. This is done using methods from numerical analysis on a computer. This course provides an introduction to numerical techniques and analysis required to find the approximate solution of partial differential equations. The course covers approximation methods for parabolic (including the time dependent heat equation), hyperbolic (including time dependent wave equations) and elliptic equations (including steady state heat equations). The course mainly covers finite difference methods, but also introduces finite element methods for elliptic problems. There is also a practical programming mini-project (using Python) to implement and test various approximation methods.

PURE MATHEMATICS D, F10PD2 (Solitons)
[Semester 2]
Solitons are localized travelling wave packets that maintain their shapes as they travel, and emerge unaltered after interacting with each other. Due to this "particle-like" nature solitons are of mathematical significance and have a plethora of realistic applications including optical fibres, water wave & tsunami formation, Bose-Einstein condensates and chemical reactions among others. In fact the soliton is part of Heriot-Watt history being discovered by J. S. Russell who noticed a solitary "wave of transition" that travelled for great distance on the Union canal just 1 mile from campus. In this course we will develop the methods to study and understand solitons. To achieve this we will first introduce basic quantum mechanical notions and in particular Schrödinger's equation and use this as a background to study non-linear systems that display soliton behaviour.

GEOMETRY, F10PG2
[Semester 2]
This course develops methods of multidimensional calculus to investigate geometrical properties of smooth curves and surfaces. The topics covered include curves in Euclidean space, vector fields and differential forms, moving frames and structure equations, surfaces in Euclidean space, curvature and geodesics.