Scottish Mathematical Sciences Training Centre

Prerequisites
The course assumes basic undergraduate knowledge of ordinary differential equations (in particular first order separable and first- and second-order linear equations); single- and multi-variable calculus; Taylor’s theorem; and linear algebra.

Overview of the stream
In applied mathematics, physical and other problems are often modelled by differential equations. It is extremely rare that one can obtain exact solutions to the differential equations that may occur in, for example, fluid dynamics, mathematical biology or magnetohydrodynamics. Additionally, the problems may involve the evaluation of integrals which arise, for example, through contour integration or Fourier or Laplace transform methods for solving ODEs. Thus, in many cases we are forced to employ some kind of approximation in order to make progress with our problem. Hence, we must obtain an approximate solution rather than the exact solution. In essence there are two main types of approximation: analytical approximations and numerical approximations.

Module 1: analytical and asymptotic methods.
(i) Asymptotic methods for differential equations, including the methods of multiple scales and matched asymptotics (lectures 1 to 6; Dr David Pritchard, Dr Stuart King and Prof. Alan Hood).
(ii) Contour integral methods for differential equations, including the method of steepest descents (lectures 7 and 8; Dr Dumitru Trucu).
(iii) Further applications of asymptotics (lectures 9 and 10; Dr Stuart King and Dr David Pritchard).

Module 2: numerical methods.
(i) Numerical methods for ODEs, including implicit, explicit and multistep methods (lectures 1 and 2; Prof. Dugald Duncan).
(ii) Numerical methods for stochastic DEs (lectures 3 and 4; Prof. Des Higham).
(iii) Numerical methods for PDEs, in particular finite-difference methods (lectures 5 to 8; Prof. Ping Lin).
(iv) Numerical linear algebra (lectures 9 and 10; Dr Victorita Dolean Maini).

Assessment
The course will be assessed by four written assignments. The provisional deadlines are:

Module 1: Assignment 1 (lectures 1–5): to be submitted by 21 November 2014.
Module 1: Assignment 2 (lectures 6–10): to be submitted by 9 January 2015.
Module 2: Assignment 1 (lectures 1–4): to be submitted by 6 March 2015.
Module 2: Assignment 2 (lectures 5–10): to be submitted by 10 April 2015.

Assignments will include both “paper and pencil” and computer work, and will be set at least two weeks before the deadline.

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