

University of Dundee

Mathematics Division

## MA41003: ODEs and their Approximation Guide 2007 - 2008

### Organisation

Lecturer: Dr David Griffiths, Room 23/1/1

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You may bring matters of concern about the course to the attention of the Mathematics Division Staff/Student Committee, which meets once each semester. A volunteer will act as class representative to sit on the Staff-Student Committee; their name will be posted on BlackBoard.

### Timetable

There will be 2 lectures and one Workshop each week for 11 weeks, though every effort will be made to complete all new material by the end of the 10th teaching week.

There will be 1 class test of one hour duration which will be held around the middle of the semester.

### Your Commitment

You are expected to attend all lectures and workshops except on medical grounds or with the special permission of the lecturer concerned. If you are absent from a Class Test on account of medical problems, you should submit a medical certificate to your Faculty Office. Outside of class hours (3 per week) personal supporting study of an additional 7 hours per week is required. This to include background reading, preparation, and writing of assessed coursework, revision for class tests and the degree examination.

### Study Support

If you are having difficulty with the course work you are encouraged to seek help at an early stage at the Workshops. You may also obtain help from the Maths Base (see BlackBoard for details); form your lectures or Personal Tutor.

### Background

Ordinary differential equations (ODEs) are an important modelling tool in Science and Engineering. These can rarely be solved exactly and so techniques have been developed to derive approximate solutions that may, in principle, be made as accurate as desired. This module examines the basic numerical methods for the approximate solution of both initial and boundary value problems (IVPs and BVPs). We describe how methods may be constructed, how they may be applied and, via aspects of convergence theory, identify the principal requirements of successful methods.

We shall also discuss eigenvalue problems and Green's functions and their role in solving BVPs.

## Syllabus

### Numerical Methods for Initial Value Problems for ODEs (10)

Taylor Series Methods.

Linear multi-step methods:

One-Step methods (Euler, Trapezoidal and Backward Euler methods).

Two-step methods: Construction, Consistency, Zero-Stability, Weak Stability Theory and A-stability.

Provision of the extra starting values and the potential for instability.

Runge-Kutta methods:

Construction and Weak Stability Theory.

Application to systems.

### Boundary Value Problems for ODEs (12)

BVPs for second order ODEs; eigenvalues and eigenfunctions; orthogonality.

Green's functions. Maximum principles.

Finite difference methods: 2nd and 4th order methods.

Treatment of boundary conditions. Maximum principles. Convergence.

## Assessment

The overall assessment will be based on Homeworks (10%), Class Test (10%) and a two hour Degree Examination (80%).

## Feedback

At the end of each section of the module you will be asked to complete a confidential questionnaire regarding the content and presentation of the module. This is an important element in the University's Academic Standards procedures.

## Recommended Books

There are many books in the library covering parts of the material in this module. The following books cover much of the module's contents between them, so they may be useful for reference and revision purposes.

1. *Numerical Methods for Ordinary Differential Systems*, J D Lambert, 1991, Wiley.  
The author's earlier book *Computational Methods in Ordinary Differential Equations* (1983, Wiley), is more accessible. Chapters 1, 2, 3.1, 3.2, 3.6, 4.1, 4.2, 4.3, 4.7 cover the material in Part 1.
2. *Elementary Numerical Analysis*, 2nd Ed. (1993).  
K.E. Atkinson,  
Chapter 9 covers much of the material in Part 1 of the course.
3. *Ordinary Differential Equations*, 1968, Blaisdell  
G.F. Carrier and C.E. Pearson,  
(Re-issued as Classics in Applied Mathematics 6, SIAM 1991).  
Chapter 17 has brief overview of techniques in Part 1. Chapter 3 (background), 6 & 7 cover some of part 2.

4. *Advanced Engineering Mathematics*  
E. Kreyszig, Wiley: 8th Edition, 1999 (other editions are likely to be similar).  
Has a short section (pages 942–959) on Part 1.
5. *Elementary Differential Equations and Boundary Value Problems*, Wiley; 7th Edition.  
W.E. Boyce and R.C. DiPrima

## Web Resources

*Advance@Dundee* <http://www.dundee.ac.uk/advancedundee/>

This is the University of Dundee Transferable Skills Website and is divided into eight key skill areas and over 60 specific topics giving access to hundreds of interlinked articles about personal transferable skills. The eight skill areas include pages on Basic Maths & Stats.

There are many other resources available on the web that are relevant to these modules, for example

[http://en.wikipedia.org/wiki/Linear\\_multistep\\_method](http://en.wikipedia.org/wiki/Linear_multistep_method)

We suggest you use Google or some other search engine.

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