Faculty of Science
School of Mathematics & Statistics

MATH5295

FINITE ELEMENTS & QUASI-MONTE CARLO METHODS

Semester 1, 2017

Math5295 – Course Outline

Information about the course

Course Authorities: A/Prof. W. McLean RC-2085, email `w.mclean@unsw.edu.au` and A/Prof. Josef Dick, RC-2074, email `josef.dick@unsw.edu.au`

Consultation: The consultation hours will be posted on Moodle (see below).

Classes: We have three hours of class contact per week:

Monday	4–6pm	Old Main Building 150
Thursday	11am–12noon	Old Main Building 151

Moodle: You can access the online materials for the course by logging on to

`https://moodle.telt.unsw.edu.au/`

Textbook: For the first half of the course you will need to purchase of copy of the textbook.

> Claes Johnson, *Numerical Solution of Partial Differential Equations by the Finite Element Method*, Cambridge University Press, 1987, Dover, 2009. **P 517.383/207**

The UNSW bookshop sells the Dover edition for $25.06 but note the comment on their web site: "In Stock - will despatch next working day. Walk-in shoppers should ring ahead to ensure shelf availability".

Course aims

Weeks 1–6 (A/Prof McLean)

This part of the course introduces the finite element method (FEM), a numerical technique for computing an approximate solution to a partial differential equation. In its standard form, the method is suitable for treating a wide class of elliptic boundary value problems, and has numerous applications in science and engineering.

We cover the mathematical basis of the finite element method and its algorithmic implementation, that is, both theoretical and practical aspects of the FEM.

Weeks 7–12 (A/Prof Dick)

High-dimensional problems, that is, problems involving hundreds or thousands of variables, are becoming ever more important, with examples from finance, health statistics, oil reservoir modeling, and physics, among others. Quasi-Monte Carlo (QMC) methods are numerical techniques which are designed for approximating high-dimensional integrals.

This part of the course introduces the theory and construction of some families of QMC methods, and shows how they can be applied to high-dimensional integrals arising from a number of practical examples. It concludes with an example where the integrand involves the solution of an elliptic partial differential equation.

Relation to other mathematics courses

The most closely related courses are Math3101/5305 Mathematical Computing and Math3311/5335 Mathematical Methods for Finance.

Assessment

You must complete the following assessment tasks:

Assignment 1 (Week 3)	5%
Assignment 2 (Week 6)	20%
Assignment 3 (Week 9)	5%
Assignment 4 (Week 12)	20%
Final Exam (2 hours)	50%

Assignments 1 and 3 will simply be a matter of handing in your solutions to some tutorial problems.

Assignments 2 and 4 will require you to develop ideas from lectures to a new setting, and may include a computing component.

The usual University rules for assignments apply:

`https://student.unsw.edu.au/plagiarism`

Additional resources and support

Moodle

We will post any course materials on the Moodle course module. In particular, you can download the lecture notes and tutorial problems.

Software for the finite element part

We will use a small finite element package written in the Julia programming language, and a mesh generation program called Gmsh. This software is free and runs on Linux, Windows and OSX.

Reference books for the finite element part

As a complement to the textbook by Claes Johnson, a good reference on the more theoretical aspects of finite elements is

> Dietrich Braess, *Finite Elements: Theory, fast solvers, and applications in solid mechanics*, Cambridge University Press, Second Edition, 2001, **P 620.00151535/20**.

The library has electronic access to the Third Edition of this work.

You might find also find the following books useful.

> Susanne C. Brenner and L. Ridgway Scott, *The Mathematical Theory of Finite Element Methods*, 2nd Edition, Springer, 2002, **P 515.35/24**.

> Gilbert Strang and George J. Fix, *An analysis of the finite element method*, 2nd Edition, Wellsley–Cambridge Press, 2008, **517.383/62 B**.

Reference books and online material for the quasi-Monte Carlo part

You might find the following books useful.

> Harald Niederreiter, *Random Number Generation and Quasi-Monte Carlo Methods*, SIAM, Philadelphia, 1992, **517.6/394**.

> Ian H. Sloan and Stephen Joe, *Lattice Methods for Multiple Integration*, Oxford University Press, Oxford, 1994, **P 517.6/432**.

> Josef Dick and Friedrich Pillichshammer, *Digital Nets and Sequences: Discrepancy Theory and Quasi-Monte Carlo Integration*, Cambridge University Press, New York, 2010, **518.282/2**.

A free online source of material on quasi-Monte Carlo methods can be found at

`http://roth.cs.kuleuven.be/wiki/Main_Page` which contains freely available books, survey articles, PhD theses and more.

The following survey paper is closely related to the lectures.

> Josef Dick, Frances Y. Kuo, and Ian H. Sloan, High dimensional integration: the quasi-Monte Carlo way. *Acta Numer.* 22, 133–288, 2013.

References to relevant journal articles will be provided in class.

Administrative matters

Additional Assessment, School Rules and Regulations

UNSW assesses students under a standards based assessment policy. For how this policy is applied in the School of Mathematics and Statistics see

`http://www.maths.unsw.edu.au/currentstudents/assessment-policies`

Plagiarism and academic honesty

Plagiarism is the presentation of the thoughts or work of another as one's own. Issues you must be aware of regarding plagiarism and the university's policies on academic honesty and plagiarism can be found at

`https://student.unsw.edu.au/plagiarism`