Spring 2014 - Math 689
Finite Element Methods for PDE

Lectures: Tu 7:20pm-10:00pm Exploratory Hall 4106

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Prerequisites. Functional analysis and PDE theory (variational method) will be reviewed. Prior exposure to graduate level PDE and MATLAB is useful but not mandatory. This course is an excellent complement to MATH 685 and 678, which cover Sobolev spaces, modern PDE theory and FEM in 1d.

Course description: This course deals with finite element for elliptic partial differential equations (PDEs) arising in science and engineering (solid and fluid mechanics, electromagnetism, thermodynamics, etc). Each topic starts with a review of basic PDE theory. The emphasis is on stability, interpolation and error estimates (a priori and a posteriori).

Below we provide further details:

FEM for elliptic problems.

1. Variational formulation of elliptic problems and examples: the inf-sup theory.
2. The finite element method and its implementation.
3. Piecewise polynomial interpolation theory in Sobolev spaces.
4. A priori error estimates and applications: quasi-uniform and graded meshes.
5. A posteriori error estimates and adaptivity: contraction property and optimality.

Text (suggested) for first part of course: [1, 5, 3, 2] and for second part of course [7, 4, 6].

Exams (30%): The FINAL exam / project will be comprehensive and will constitute 30% of the grade.

Homework (70%): There will be about 6 HOMEWORKS which will amount to 70% of the final grade. The homeworks will be about 80% theoretical and 20% computational using MATLAB. There will be a penalty of 10% per day late; homeworks will not be accepted after one week.

Students are encouraged to work in groups of up to three students but must hand in an individual self written proofs and answers.

Academic Integrity: GMU is an Honor Code university; please see the Office for Academic Integrity for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. What does academic integrity mean in this course? Essentially this: when you are responsible for a task, you will perform that task. When you rely on someone elses work in an aspect of the performance of that task, you will give full credit in the proper, accepted form. Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind) please ask for guidance and clarification.

Mason email accounts. Students must use their MasonLIVE email account for any correspondence during this course. For more information see: `http://masonlive.gmu.edu`.

Office of Disability Services. If you are a student with a disability and you need academic accommodations, please see me and contact the Office of Disability Services (ODS) at 993-2474, `http://ods.gmu.edu`. All academic accommodations must be arranged through the ODS.

University policies The University Catalog, `http://catalog.gmu.edu`, is the central resource for university policies affecting student, faculty, and staff conduct in university academic affairs. Other policies are available at `http://universitypolicy.gmu.edu`. All members of the university community are responsible for knowing and following established policies.

References

[1] D. Braess. *Finite Elements. Theory, Fast Solvers, and Applications in Solid Mechanics*. Cambridge University Press, Cambridge, New York, 1997.

[2] S. C. Brenner and L. R. Scott. *The Mathematical Theory of Finite Element Methods*, volume 15 of *Texts in Applied Mathematics*. Springer, New York, third edition, 2008.

[3] P. G. Ciarlet. *The finite element method for elliptic problems*, volume 40 of *Classics in Applied Mathematics*. Society for Industrial and Applied Mathematics (SIAM), Philadelphia, PA, 2002. Reprint of the 1978 original [North-Holland, Amsterdam; MR0520174 (58 #25001)].

[4] M. C. Delfour and J.-P. Zolésio. Shape analysis via distance functions: local theory. In *Boundaries, interfaces, and transitions (Banff, AB, 1995)*, volume 13 of *CRM Proc. Lecture Notes*, pages 91–123. Amer. Math. Soc., Providence, RI, 1998.

[5] S. Larsson and V. Thomée. *Partial differential equations with numerical methods*, volume 45 of *Texts in Applied Mathematics*. Springer-Verlag, Berlin, 2009. Paperback reprint of the 2003 edition.

[6] B. Mohammadi and O. Pironneau. *Applied shape optimization for fluids*. Numerical Mathematics and Scientific Computation. Oxford University Press, Oxford, second edition, 2010.

[7] J. Sokołowski and J. P. Zolésio. *Introduction to shape optimization*, volume 16 of *Springer Series in Computational Mathematics*. Springer-Verlag, Berlin, 1992. Shape sensitivity analysis.