Mathematics 784, Spring 2013
Nonlinear Equations and Unconstrained Optimization
House Rules

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| Instructor: | Tim Kelley | Office: SAS 3234, x57163<br>Email: Tim_Kelley@ncsu.edu<br>Office Hours: TBA |
| WWW | http://www4.ncsu.edu/~ ctk/ (Tim)<br>http://www4.ncsu.edu/~ ctk/ma784.html (Course)<br>http://www4.ncsu.edu/~ ctk/house_784/house.html (this document)<br>http://www.siam.org/books/textbooks/fr16_book.pdf (download nonlinear equations book)<br>http://www.siam.org/books/textbooks/fr18_book.pdf (download for optimization book | |
| Books: | Iterative Methods for Linear and Nonlinear Equations<br>C. T. Kelley, SIAM, 1995<br>Iterative Methods for Optimization<br>C. T. Kelley, SIAM, 1999<br>**Download books free from SIAM** | |
| Prerequisites: | Advanced Calculus (MA 511/2), MA 580, Knowledge of Matlab | |
| Grade: | Homework and Programs (40%), Presentation (60%)<br>Homework must be in typeset (TeX, LaTeX, troff,WORD, ...)<br>Auditors may do as much as they wish. | |
| Computing: | NCSU UNIX Workstations in your college or department.<br>University charge applies. | |
| Language: | MATLAB | |

We provide software tools (e.g. GMRES, PCG, some solvers) in MATLAB. You'll need MATLAB v 2010a or higher.

Important Dates

- Thursday, February 21, 1st homework assignment due
- Tuesday-Thursday, March 5,7: No class, Spring Break
- Tuesday, March 19, 2nd homework assignment due
- Thursday, March 28: No class, Spring Holiday
- Tuesday, April 23, 3rd homework assignment due
- Friday, April 26: Classes end

## Homework

There will be three sets of homework. You must do

- at least one problem from each set, and
- at least six problems in total.

It is ok to do the homework in teams of no more than five people. Those of you who plan to get degrees in numerical analysis should do **more than the minimum** six problems.

## Approximate Schedule of Topics

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| Week 1–2 | Nonlinear equations/optimization in one variable. |
| Week 2–3 | Review of advanced calculus and numerical linear algebra. |
| Week 3–6 | Newton's method and variations in several variables. Newton Iterative Methods. |
| Weeks 6–7 | Broyden's method, proof of superlinear convergence. |
| Week 9 | Unconstrained Optimization, Newton's method for unconstrained optimization. |
| Week 10–11 | Globally convergent variations of Newton's method. |
| Week 11–12 | Nonlinear least squares, Quasi-Newton methods for unconstrained optimization. |
| Weeks 13–14 | Student presentations. |

## Things for you to do.

1. Learn LaTeX (or some other technical wordprocessing program) and MATLAB if you have not already done so. An old version of the MATLAB Primer [11] is available on the course web page. The book by Higham and Higham (see reference list) is also very good. There is considerable help with MATLAB and LaTeX on the course web page.
2. Start thinking about your presentation. I'd like it to be related to your own research interests. Those of you who are not math majors are welcome to prepare something on nonlinear equations/optimization problems in your thesis work. If you have an idea for a presentation, come talk to me about it.

## REFERENCES


[1] J. W. DEMMEL, *Applied Numerical Linear Algebra*, SIAM, Philadelphia, 1997.

[2] J. E. DENNIS AND R. B. SCHNABEL, *Numerical Methods for Unconstrained Optimization and Nonlinear Equations*, no. 16 in Classics in Applied Mathematics, SIAM, Philadelphia, 1996.

[3] G. H. GOLUB AND C. G. VANLOAN, *Matrix Computations*, Johns Hopkins studies in the mathematical sciences, Johns Hopkins University Press, Baltimore, 3 ed., 1996.

[4] D. J. HIGHAM AND N. J. HIGHAM, *MATLAB Guide*, SIAM, Philadelphia, 2000.

[5] E. ISAACSON AND H. B. KELLER, *Analysis of numerical methods*, Wiley, New York, 1966.

[6] L. KANTOROVICH AND G. AKILOV, *Functional Analysis*, Pergamon Press, New York, second ed., 1982.

[7] C. T. KELLEY, *Solving nonlinear equations with Newton's method*. Book manuscript, to appear in SIAM series on Fundamental Algorithms for Numerical Calculations, 2003.

[8] ———, *Iterative Methods for Linear and Nonlinear Equations*, no. 16 in Frontiers in Applied Mathematics, SIAM, Philadelphia, 1995.

[9] ———, *Iterative Methods for Optimization*, no. 18 in Frontiers in Applied Mathematics, SIAM, Philadelphia, 1999.

[10] J. M. ORTEGA AND W. C. RHEINBOLDT, *Iterative Solution of Nonlinear Equations in Several Variables*, Academic Press, New York, 1970.

[11] K. SIGMON AND T. A. DAVIS, *MATLAB Primer, Fourth Edition*, CRC Press, Boca Raton, FL, 6 ed., 2002.

[12] G. W. STEWART, *Introduction to matrix computations*, Academic Press, New York, 1973.

[13] L. N. TREFETHEN AND D. BAU, *Numerical Linear Algebra*, SIAM, Philadelphia, 1996.