Course: ENGRD 241/CEE 241 (CU), G1462 (UC)

ENGINEERING COMPUTATION

GENERAL INFORMATION

1st semester
Credits: 5CU-6UC
Lectures: Monday 11:00-13:00. Tuesday and Thursday: 13:00-14:00.

INSTRUCTORS

AMPARO GIL (amparo.gil@unican.es)
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COURSE OBJECTIVES

The main objective of the course is to introduce numerical methods as a fundamental tool for engineering disciplines. We plan to review some main topics of Numerical Algebra (matrix calculations, systems of equations,…) and Numerical Calculus (root finding, interpolation, differentiation and integration, numerical methods for initial and boundary value problems in differential equations,…), with the perspective given by the availability of a computer and working with computational efficiency and controlling the errors . Computer tools and programming will be important; we will use software widely used in engineering and science (MATLAB,,..). We will illustrate and discuss how numerical methods are used in practice, considering examples from Engineering.

BASIC REFERENCES

- Lecture notes (web page of the course)
- "Numerical Methods for Engineers", 6th, 5th editions, Steven C. Chapra and Raymond P. Canale
ISBN: 978-0-07-340106-5, Publisher: McGraw-Hill Book Company, New York, Published 2010, 2005

OTHER REFERENCIES

- Quarteroni, A. et al. "Scientific Computing with MATLAB and Octave". Springer Verlag. 2006
- Burden, R. L., Faires J.D. “Numerical Analysis”, 9th ed. Brooks/Cole Ed. 2010.
- Atkinson, K.E. "An introduction to Numerical Analysis". John Wiley & Sons, New York, 2nd Edition, 1989.
- Gockenbach, M.S. "Partial Differential Equations: Analytical and Numerical Methods". SIAM. 2002.
- Fish, J., Belytschko, T. "A First Course in Finite Elements". John Wiley&Sons. 2007

GRADING

Computer Assignments (CA)	20%
For 2 Prelims	40% (November and January)
Final Exam	20% (End of January)
Problem Sets/Computing Lab, participation, etc.:	20%

ADDITIONAL INFORMATION

- Lecture notes and homework assignments will be posted regularly in the course web pages:

http://personales.unican.es/puigpeyj/EngComp2011.htm

http://personales.unican.es/gila/UC-Cornell2012.pdf

- Allowed material in the exams:
. Prelim: one A4 size paper sheet handwritten on both sides with personal annotations.
. Final: two A4 size paper sheets handwritten on both sides with personal annotations.
(A hand calculator is also permitted during the exams, though each step in any calculation must be detailed and explained)

- Teams of 2 or 3 students will be organized to prepare Computer Assignments and Problem Sets.

COURSE SYLLABUS

(ch # refers to chapter # of Chapra & Canale book)

W	D	Topic Lecture	Topic Lab	Assignment due
1	24/ 09	Course presentation. Numerical methods and engineering problems. Modeling, approximations, types of errors (ch 1,2,3)	Introduction to Matlab. Simple truss application program.	
2	1/ 10	Taylor series. Application to numerical differentiation. Formulas and errors. Applications.(ch 4)	Computational experiments with rounding errors and truncation errors	Problem Set 0
3	8/ 10	Roots of equations. Bracketing: bisection, false position. Open methods: Newton, secant, fixed point. (ch 5)	Programming the solution of nonlinear equations and systems	Computer Assignment 1
4	15/ 10	Error and convergence in root finding. Newton-Raphson method for solving systems of nonlinear equations. (ch 6)	Programming the solution of nonlinear equations and systems	
5	22/ 10	Systems of linear equations. Gaussian elimination. Errors and pivoting strategy. Counting operations. Matrix inversion. Matrix factorization : LU, Cholesky, ….(ch 9,10)	Programming the solution of linear equations systems. Direct methods.	Problem Set 1
6	29/ 10	Errors in linear systems. Norms, condition number. Iterative methods for linear systems: Jacobi, Gauss-Seidel. Convergence (ch 10,11)	Programming the solution of linear equations systems. Iterative methods.	Computer Assignment 2
7	5/ 11	Data fitting: least squares. Engineering examples. Interpolation: divided differences, Lagrange functions. Cubic splines. (ch 17,18)	Programming data fitting by least squares	
8	12/ 11	Numerical Integration. Interpolatory quadrature formulas. Newton-Cotes simple and composite rules. Errors. (ch 21,22)	Computing polynomial interpolation	Problem Set 2 Computer Assignment 3
9	19/ 11	High precision quadrature rules: Gaussian quadrature. Domain transformations. Multiple integrals. Monte Carlo methods. Case studies.(ch 21,22)	Programming N-C rules and their performance	Computer Assignment 4
10	26/ 11	Ordinary differential equations (ODE's). Initial value problems Single step methods: Taylor and Runge-Kutta. Errors. (ch 25)	Programming domain transformations and multiple integrals	Problem Set 3 **Prelim 1**
11	3/ 12	Initial value ODE's: Multistep methods. Predictor corrector. Stiffness. Engineering case studies.(ch 26,28)	Programming single step methods for initial value ODE's. Determine convergence rate.	Computer Assignment 5
12	10/ 12	Boundary value problems (BVP) in ODE's. Shooting methods. Finite differences. Engineering problems. (ch 27,28)	Performance of numerical methods for stiff problems. Shooting methods for BVP	Problem Set 4 Computer Assignment 6
13	17/ 12	Basic finite elements for BVP in ODE's. Weighted residuals. Implementation aspects. (ch 31)	Programming finite difference and finite element methods for ODE's	Computer Assignment 7
14	7/ 01	2nd order linear partial differential equations (PDE's). Stationary flow: heat, porous media. Finite difference methods. (ch 29)	Programming finite difference and finite element methods for ODE's	Computer Assignment 8
15	14/ 01	Time dependent problems in PDE's. Parabolic flow. Finite differences schemes: explicit, implicit. Convergence and stability.(ch 30,32))	Programming finite difference methods for PDE's	Computer Assignment 9 **Prelim 2**

FINAL EXAM: 29 January 2012