SUBJECT PRESENTATION FORM

Subject name	NUMERICAL ANALYSIS
Field of study	Civil Engineering
Main field of study	Civil Engineering
Subject code	41322008
Subject main teacher	Prof. Adrian CHISĂLIȚĂ, Mac(Eng), BSc(Math), PhD
Collaborators	Dragoș F. Lisman MSc(Eng)
Department	Structural Mechanics
Faculty	Civil Engineering (Construcții)

Sem.	Type of subject	Course	Applications			Course	Applications			Individual Study	TOTAL	Credits	Type of examination
		[Classes/week]				[Classes/semester.]							
			S	L	P		S	L	P				
3	**Fundamental**	**2**	**-**	**2**	**-**	**28**	**-**	**28**	**-**	**22**	**78**	**3**	**Exam**

Prerequisites: Differential Calculus; Fortran 90/95 programming language.
Theoretical knowledge, (What the students must know)
Aim: An introduction to Scientific Computation: Applied Numerical Analysis, with problems solved on computer.
Achieved skills: (What they can do)
- The student is supposed to be able to handle most of numerical methods for solving equations; and, be able to analyze the accuracy and the stability of a numerical method. - At the same time, the student has to manage the use of library routines for building a project in order to solve a computational problem.
Achieved abilities: (What types of equipments and instruments they know how to use)
- To use a PC with Windows OS; - To use the development environment of MS Visual Studio and CVF (Compaq Visual Fortran).

A. Course (*Lecture title* +curriculum)	
1	*Object of Numerical Analysis:* Object. Problem conditioning, condition number; Examples. Algorithm stability. Conclusions regarding problem conditioning and algorithm stability. *Computer representation of numbers:* Integers.
2	*Computer representation of numbers:* Reals, floating-point representation: Representation models (scientific; binary computer). Format structure; IEEE Formats. Special values; Representation range.
3	*Computer representation of numbers – Rounding error measure:* ULP; machine-ε; Unit rounding error. *Errors, sources and propagation:* Error; Relative error; Significant digits**.** Error sources. Rounding error**.** Truncation case. Examples for base $\beta = 2$.
4	*Errors, sources and propagation – Error propagation:* Propagated error. Multiplication; Division; Function evaluation. Loss of signification error. Addition and subtraction. Propagation of errors in a sum. *Nonlinear equations:* Method and method analysis; Order of convergence. Linear convergence.
5	*Roots of an equation f(x) = 0:* Bisection method. Secant method. Newton method; Error estimation; Comparison with Secant method.
6	*Fixed-Point method:* Method. Convergence (contractive mapping). Error evaluation. Geometrical interpretation. The stationary process.
7	*Fixed-Point method:* Explicit Fixed-point procedures. Higher order Fixed-point methods. *Root of a polynomial*: Polynomial evaluation; Newton method for polynomials.
8	*Root of a polynomial*:

	Strategies: Deflation; Direct Iteration. Complex roots (elements); Laguerre Method. Stability of the roots.
9	*Multiple roots of equation f(x) = 0*: Problems. Newton method and Modified Newton method. *Systems of non-linear equations:* Definitions. Norms. Fixed-Point Method.
10	*Systems of non-linear equations:* Explicit fixed-point procedure: Iteration with constant matrix **A** (updated). Newton method; Convergence; Practical iteration scheme. Newton-like methods. *Linear systems of equations:* General considerations. Gauss elimination.
11	*Linear systems of equations:* Pivoting. Number of operations. Matrix inversion. LU decomposition. Direct evaluation of LU factors, methods.
12	*Linear systems of equations:* Cholesky method. Iterative methods: Jacobi. Gauss-Seidel. SOR.
13	*Linear systems of equations:* Solution stability and error analysis: Condition number. Well- and ill-conditioned matrices. *The Matrix Eigenvalue Problem*: Eigenvalues & eigenvectors.
14	*The Matrix Eigenvalue Problem*: Characteristic polynomial. Properties of eigenvalues; Properties of eigenvectors. Hermitian matrices.

B1. Applications – **WORKS** (list of works, seminar works, contents of the year end project)	
1	Developer Studio Recall; Project structure; Building a project. Use of ANA Library. Algorithm stability (Bessel function: direct and recursion computation)
2	Computer representation of numbers. Bitview utility: integers; reals. Special values.
3	ULP; machine-ε; Unit rounding error. Intrinsic Fortran functions returning representation parameters.
4	Errors: loss of significance; Rump ” polynomial”. Summation: Harmonic series; SSH problem.
5	Bisection method. Secant method.
6	Newton method. Fixed-point method.
7	Fixed-point method: Stationary process. Explicit procedures.
8	Roots of polynomials; Stability of the roots.
9	Non-linear systems: Fixed-point method: Iteration with constant matrix **A**. Newton method.
10	Linear systems: Gauss; Pivoting. Matrix inversion.
11	Linear systems: LU. Cholesky.
12	Linear systems: Iterative methods.
13	Linear systems: Condition number.
14	Eigenvalues: Characteristic polynomial; Eigenvectors.

B2. Laboratory room (Room/surface, address) 306/58 m^2 and 505/58m2; Daicoviciu Street No.15, Tower Building, 3rd & 5thfloor.

Equipment	Equipment description	Year of purchase
Computers Room 306: 8 pcs. Room 505: 8 pcs.	PC- Processor Pentium IV/3GHz/Memory 512MB/ HDD 80GB/DVD-RW/Monitor CRT 17”/Keyboard & Mouse; PC- Procesor Pentium III/600-700MHz/Memory 64MB/ HDD 20GB/Monitor CRT 15”-17” ”/Keyboard & Mouse.	2005 2000
Software Room 306 Room 505	MS Windows XP Professional, SP2 MS Office 2003 (room 306); MS Office 2000 (room 505). Compaq Visual Fortran 6.6C; Array Visualizer 1.5 MS Windows 2000 + SP4 MS Office 2000 Compaq Visual Fortran 6.6C; Array Visualizer 1.5	2005 2003 2001 2000 2000 2001

C. Individual study (topics of the bibliographical studies, summarized materials, projects, applications etc.)

1. Fortran 90/95 programming.
2. ANA sources & Examples.

3. Computer representation of numbers. 4. Exam Problem.

Structure of the Individual study	Course study	Solving homework, labs, projects	Training, applications	Time allotted for examinations	Bibliographical supplementary study	Total number of classes for individual study
No. of classes	14	2	0	1	5	22

D. Teaching methods and strategies
1. Course: Lectures. 2. Laboratory: Computer work, problem solving. Based on ANA Library & ANA User's Guide. 3. Exam Problem: Two problems (randomly chosen) are given to each student at Lab #13, to be solved and be presented at the end-of-semester exam. The list of Problems is posted on ftp.utcluj.ro.

Bibliography

1. Chisalita A., "Numerical Analysis", UTC-N, 2002.
2. Chisalita A., "ANA – Numerical Analysis Library (source code)", UTC-N, 1991-2011.
3. Chisalita A., "ANA – User's Guide", UTC-N, 2011.
4. Atkinson K.E., "An Introduction to Numerical Analysis", John Wiley & Sons, N.Y., 1978
5. Atkinson K.E., "Elementary Numerical Analysis", 2nd edition, John Wiley & Sons, N.Y., 1993
6. Curtis F.G., "Applied Numerical Analysis", Addison-Wesley Publishing Company, Inc., 1978
7. Isaacson E., and Keller H.B., "Analysis of Numerical Methods", John Wiley & Sons, N.Y., 1966
8. Kincaid D., and Cheney W., "Numerical Analysis", 2nd edition, Brooks/Cole Publ. Co., 1996
9. Ralston A., and Rabinowitz Ph., " A First Course in Numerical Analysis", McGraw-Hill, Inc., 1978
10. "Compaq Visual Fortran Language Reference Manual", 2001
11. "Compaq Visual Fortran Programmer's Guide", 2001
12. "Intel Fortran Compiler 11.1 User and Reference Guide", 2011
13. "IMSL Mathematical and Statistical Libraries", Compaq Visual Fortran 6.6, IMSL Help, 1999.
14. "High-Precision Software Directory", 2010, http://crd.lbl.gov/~dhbailey/mpdist/

Examination and grading procedure	
Examination procedure	Oral Examination. 1. One Theoretical Question: picked by the student from a lot of questions. The list of Theoretical Questions is posted on ftp.utcluj.ro, the last day of the semester. 2. Two Problem: pre-solved and presented (on computer).
Components of the grade	1. Theory Mark; 2. Problem marks; 3. Up to 1 point Bonus, for Lab attendance (Bonus = Lab attendance/No_of_Labs).
Formula for calculating the grade	Final mark = (Theory mark + Problem marks)/3 + Bonus – if applicable. Condition for passing: Each of Theory and Problem marks be ≥ 5. The bonus is granted at the 1st attendance to the exam, and only if the passing condition is fulfilled.

Subject coordinator,
Prof. **Adrian CHISALITA**