COURSE OUTLINE

1. GENERAL

SCHOOL	CIVIL ENGINEERING		
ACADEMIC UNIT			
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	1001	**SEMESTER**	3
COURSE TITLE	NUMERICAL ANALYSIS		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits/ ECTS*	**WEEKLY TEACHING HOURS**	**CREDITS/ ECTS**
Various teaching forms	4	4
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at 4.		

COURSE TYPE: *general background, special background, specialised general knowledge, skills development*	General background
PREREQUISITE COURSES:	[KNOWLEDGE BACKGROUND REQUIRED]: Mathematical Analysis and Linear Algebra.
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK
IS THE COURSE OFFERED TO ERASMUS STUDENTS:	NO
COURSE WEBSITE (URL):	https://helios.ntua.gr/enrol/index.php?id=1520.

2. LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.
Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the*
- *European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The course aims at acquiring the knowledge for:
-The solution of systems of linear equations, non-linear algebraic equations, ordinary Differential equations, interpolation and approximation of data and numerical approximation of integrals.
-The aim of the course is to understand the importance of numerical methods for solving scientific and technological problems for which either there is no analytical solution, or it is very difficult to calculate it.
-A secondary objective is to familiarize students with: (a) constructing iterative methods to approximate numerical solutions to problems; and (b) convergence of iterative methods.

On completion of this course, students should be armed with numerical and computational techniques for solving a wide variety of fundamental mathematical problems that arise in diverse scientific areas.
In particular, upon successful completion of the course, the student will

- understand the basic methods of Numerical Analysis a) to solve linear systems, non-linear equations and differential equations; b) to interpolate and approximate data and c) to approximate integrals.
- be familiar with the tools and techniques of iterative methods and can effectively use the appropriate stopping criteria.
- be aware of the importance of using stable algorithms to ensure the reliability of the results derived by the numerical methods.
- be able to distinguish the differences between the methods and choose the most appropriate to solve each problem.
- be able to analyse a) the asymptotic properties and the behaviour of the approximate models b) the numerical stability of the numerical solutions and c) the algorithmic and computational properties

corresponding to the numerical methods.

- understands the effect of round-off errors in the computations and truncation errors of the methods and be able to calculate error bounds of approximate solutions.
- be able to work with his / her colleagues to solve complex practical problems using the methods of Numerical Analysis

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information,
with the use of the necessary technology
Adapting to new situations
Decision-making
Working independently
Team work
Working in an international environment
Working in an interdisciplinary environment
Production of new research ideas
Project planning and management
Respect for difference and multiculturalism
Respect for the natural environment
Showing social, professional and ethical responsibility and sensitivity to gender issues
Criticism and self-criticism
Production of free, creative and inductive thinking
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Others…

- implementing knowledge in practice.
- analyzing and synthesizing data and information.
- working autonomously.
- working in teams.
- working in an international environment.
- working in an interdisciplinary environment.
- advance free, creative and causative thinking.

3. SYLLABUS

i. Number representation in computers. (1x2=2hours).
ii. Numerical solution of Linear Systems: Direct Methods: Gauss elimination method, computation of the inverse and the determinant of a matrix. Factorization methods. Vector norms, Matrices norms. Stability of linear systems. Iterative methods: General iterative method, methods Jacobi, Gauss-Seidel and SOR. (9x2=18h).
iii. Solving Non-Linear equations and systems. Roots detection. Methods: Bisection, Regula-Falsi, Fixed Point iterative method, Newton-Raphson and Secant. Newton-Raphson method for nonlinear systems. (8x2=16h).
iv. Interpolation: Polynomial Interpolation in Lagrange and Newton form and Interpolation Error. (2x2=4h).
v. Numerical Integration: Newton-Cotes formulas, Simple and Composite Trapezoidal and Simpson integration rules. Integration Gauss. (2x2=4h).
vi. Approximation Theory: Discreate least squares, polynomial and exponential approximation. (2x2=4h).
vii. Numerical solutions of Differential Equations: Initial values Problem for ordinary differential equations. Single step methods (Euler, Taylor, Runge-Kutta). Multi-step methods (Adams, Predictor-Corrector). Boundary value problems. Numerical solution of systems of differential equations. (2x2=4h).

4. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY: *Face-to-face, Distance learning, etc.*	Face-to-face lectures
USE OF INFORMATION ANDCOMMUNICATIONS TECHNOLOGY: *Use of ICT in teaching, laboratory education,communication with students*	Support learning through the online platform Helios https://helios.ntua.gr/enrol/index.php?id=1520. Students solve simple problems using calculator or appropriate software.

TEACHING METHODS: *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of nondirected study according to the principles of the ECTS*	***Activity***	***Semester workload (hours)***
	Lectures including theory as well as theoretical and computational exercises that focus on the application of Numerical Analysis methodologies.	52
	Autonomous study.	39
	Solving homework exercises (individual work).	13
	Solving sets of exercises per chapter. (teamwork).	21
	Course total:	**125**
STUDENT PERFORMANCE EVALUATION: *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically defined evaluation criteria are given, and if and where they are accessible to students.*	Language of evaluation: Greek i. Written final exam based on the material taught in the next nine weeks of the semester. (100% of the final grade) which includes: - Questions of theory. - Description of Methods. - Proof of theorems. - Solving problems with quantitative data. - Computational exercises using a calculator. ii. Optional written projects that count additively to the final degree. The evaluation criteria are explicitly defined and accessible by the students on the course web site at Helios https://helios.ntua.gr/enrol/index.php?id=1520.	

5. ATTACHED BIBLIOGRAPHY

-Suggested bibliography:

- Bradie B., A Friendly Introduction to Numerical Analysis, Pearson Education International, 2006.
- Burden R. and Faires D., Numerical Analysis, 9th Edition, Brooks/Cole, Cengage Learning, 2010.
- Sauer T, Numerical Analysis, Pearson Addison Wesley, 2006.
- Süli E. and Mayers D., An Introduction to Numerical Analysis, Cambridge University Press,2003.

-Related academic journals:

- IMA Journal of Numerical Analysis.
- Mathematics of Computation.
- SIAM Journal on Numerical Analysis.