COURSE OUTLINE

1. GENERAL

SCHOOL	SCHOOL OF ENGINEERING		
ACADEMIC UNIT	COMPUTER ENGINEERING AND INFORMATICS		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	CEID_NE509	**SEMESTER**	7TH or 9TH
ΤΙΤΛΟΣ ΜΑΘΗΜΑΤΟΣ	ECONOMIC THEORY AND ALGORTHMS		

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*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures, Recitation sections, Laboratory exercises	2(L) 2(RS) 1(LE)	5
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).	TOTAL	5

COURSE TYPE *General background, special background, specialised general knowledge, skills development*	specialised general knowledge skills development
PREREQUISITE COURSES:	There are no prerequisite courses. It is however recommended that students have at least a basic mathematical background, and prior involvement with the courses “Discrete Mathematics” (NY109), “Graph Theory and Applications” (NY202), “Introduction to Algorithms” (NY205), “Theory of Computation” (NY301), and “Computational Complexity” (NY302)
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek. Instruction may be given in English if foreign students attend the course.
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES (English)
COURSE WEBSITE (URL)	https://eclass.upatras.gr/courses/CEID1265/

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*

After the successful completion of the course, the student will be able:

- To recognise and analyse impartial combinatorial games, with respect to their final outcome, exploiting NIM heaps calculus and the MEX rule.
- To model situations of coordination or antagonism among distinct entities as either extensive-form games or normal-form (aka strategic) games.
- To understand fundamental solution concepts for different types of games, such as subgame-perfect equilibria for extensive-form games, Nash equilibria and correlated equilibria for normal-form games, Nash bargaining solutions for negotiations, etc.
- To construct subgame-perfect equilibria via backward induction, for extensive-form games of complete information.
- To understand and exploit the connection of extensive-form games with strategic games.
- To apply the methods of differences and upper-envelope, for the construction of all the Nash equilibria in two-players strategic games with one player having two actions.

- To compute MAXMIN strategies in two-players strategic games, via linear-programming techniques.
- To execute algorithms for computing one Nash equilibrium in two-players strategic games, such as linear programming for matrix games and Lemke-Howson for the general case.
- To understand the importance of approximate Nash equilibria and to execute computationally efficient algorithms for their construction, in two-players strategic games.
- To model real-world problems of competing for the exploitation of shared resources as congestion games and potential games in general, and to determine the potential functions that characterize them.
- To analyse the quality of strategic games with respect to their worst-case or best-case behaviour, using the potential-function method.
- To design sealed-bid auctions, like Vickrey auctions and Generalized VCG mechanisms.
- To understand the importance of truthfulness of the bidders and to realize whether specific auctions fulfill this property.
- To analyse interaction scenarios in cooperative environments, like negotiations and bargaining, and to predict the resulting equilibrium states (e.g., Nash bargaining solutions).
- To perceive game theory as a novel model for designing and analysing the behaviour of autonomous entities, algorithms and mechanisms, which must interact cooperatively or non-cooperatively, within a common decentralised computing environment.
- To apply voting rules and to recognise when a voting system is vulnerable to manipulation.

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

Search for, analysis and synthesis of data and information, with the use of the necessary technology
Decision-making
Working independently
Team work
Criticism and self-criticism
Working in an interdisciplinary environment
Production of new research ideas
Production of free, creative and inductive thinking

3. SYLLABUS

Combinatorial Games: Definitions, solution methods for impartial combinatorial games (NIM-heaps arithmetic, MEX-rule). **Extensive-Form Games**: Game-tree representation, complete/incomplete information games, games with perfect recall. **Strategic Games:** Zero-sum games, mixed strategies, best response strategies, dominant strategies, Nash equilibria, correlated equilibria, approximate equilibria. Algorithms and complexity for computing one/all Nash equilibria (enumeration methods, upper-envelope method, Lemke-Howson, etc.) for bimatrix games. Definition and efficient computation of MAXMIN strategies. **Negotiations**: Modelling as repeated games, with payoff discounting. Axiomatic characterization and efficient computation of Nash bargaining solutions. **Mechanisms:** Design of truthful mechanisms. Gibbard-Shatterthwaite Theorem. Auction theory. Vickrey auctions. VCG mechanisms. Generalized second-price auctions. **Congestion games:** Modelling as potential games. Evaluation methods for Price of Anarchy/Stability. Network design games. **Voting theory:** Voting rules (majority, veto, Borda, dictatorship). Arrow's Theorem.

4. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face to face

USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	ICT is used in teaching (lecture notes and slides in electronic form, use of internet sources, etc) and for communication with the students who are enrolled for the course (email list, announcements, course calendar, allocation and submission of home assignments, course site)
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 non-directed study according to the principles of the ECTS.*	
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, shortanswer 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 (English, if needed, e.g., for Erasmus+ students) **Assessment method:** The assessment consists of two components, the home assignments (delivered either individually or in pairs) and the final examination. **Home assignments:** They consist of a theoretical part, and a programming part. There are two deliverables per home assignment, the source codes of the implemented methods and a report presenting an overview of the implementation and the experimental evaluation of the implemented methods. **Final examination**: It is written, of graded difficulty, and may contain multiple-choice questions, questions that require mathematical proofs and the development of concrete arguments, or problems and exercises (e.g., execution of an algorithm for the construction of some kind of equilibrium).

Activity	***Semester Workload***
Lectures	26
Recitation sections	26
Laboratory exercises	13
Independent study	60
Course total	***125***

5. ATTACHED BIBLIOGRAPHY

Suggested Bibliography:

- McCain Roger A.: Game Theory (Greek version: 1/2019). EUDOXUS code: 86056102. ISBN: 9789925575404. Publisher: BROKEN HILL PUBLISHERS LTD .
- G. Stamatopoulos: Game Theory (in greek: 1/2016). EUDOXUS code: 320188. ISBN: 978-960-603-349-0. Type: e-book. Publisher: Kallipos Repository of Hellenic Academic ebooks.
- B. von Stengel: Game Theory Basics. Cambridge University Press, ISBN 9781108910118 (2020).
- T. Roughgarden: Twenty Lectures on Algorithmic Game Theory. Cambridge University Press (2016).
- N. Nisan, T. Roughgarden, E. Tardos, & V. Vazirani (editors). Algorithmic Game Theory. 2007.
- F. Brandt, V. Conitzer, U. Endriss, J. Lang, & A. Procaccia (editors). Handbook of Computational Social Choice. Cambridge University Press, 2016.
- D. Easley & J. Kleinberg. Networks, Crowds, and Markets: Reasoning about a Highly Connected World. Cambridge University Press, 2010.

Related academic journals:

The course is related to research topics which are very hot nowadays. Related research papers are published in high quality journals of Theoretical Computer Science (such as the Journal of the ACM, SIAM Journal on Computing, and ACM Transactions on Algorithms), Artificial Intelligence (such as Journal of Artificial Intelligence Research and Artificial Intelligence), Economic Theory (such as the Journal of Economic Theory, Games and Economic Behavior, and Econometrica), as well as interdisciplinary (such as ACM Transactions on Economics and Computation).