UNIVERSITY OF CRETE
SCHOOL OF SCIENCES
COMPUTER SCIENCE DEPARTMENT

Regulation of the Programme of Graduate Studies in Computer Science and Engineering

Computer Science Department
Voutes Campus
University of Crete
70013 Heraklion, Crete
E-mail: csd@csd.uoc.gr
URL: http://www.csd.uoc.gr

May 2023

1 The Programme of Graduate Studies in Computer Science and Engineering of the Computer Science Department

Graduate studies are organized according to article, N. 4957/2022 FEK A' 141/21.07.2022 and are regulated by Greek Law and regulations listed in this document. Graduate studies include participation in courses and seminars, participation in research and educational activities that take place within the Department, participation in examinations, and the conduct of a complete, original, research project. The Programme of Graduate Studies (Programme) awards:

Master of Science Diploma in "**Computer Science and Engineering**".

The Programme is organized around the following thematic areas:

A. Computing Infrastructures

(A1) Computer architecture and microelectronics
(A2) Computer systems, parallel and high performance computing
(A3) Computer security and distributed systems
(A4) Computer networks, mobile computing, and telecommunications
B. Theory, Software and Data
(B1) Algorithms and systems analysis
(B2) Databases, information and knowledge management
(B3) Software engineering and programming languages
(B4) Artificial Intelligence and machine learning
C. Computer Science and Engineering Applications
(C1) Signal processing and analysis
(C2) Computer vision and robotics
(C3) Computer graphics and human-computer interaction
(C4) Bioinformatics, medical informatics, and computational neuroscience

The Programme's objective is specialization into one or two thematic areas of Computer Science and Engineering, so that alumni awarded the title will have increased capabilities to contribute in industrial research and product development.

2 Administration of the Programme

The Faculty Assembly of the Department is responsible for all issues that may arise with respect to the Graduate Programme. The Faculty Assembly assigns the members of the Committee of Graduate Studies, which is formed by five members of the Department Faculty, elected by the Faculty Assembly for two year assignments. The Director of Graduate Studies presides of the Committee, of which they are a member. The Director and their replacement in the Committee are also elected by the Faculty Assembly for two year assignments. The Committee of Graduate Studies is responsible for the observation and conduction of the function of the Programme, processes issues related to the Programme, and can bring issues in front of the Faculty Assembly. The Director of the Programme is responsible for the conduction and proper function of the Programme with respect to its academic and administrative parts, they preside over and organize the Committee of Graduate Studies, they bring issues, proposals and decisions of the Committee to the Faculty Assembly and can deliver suggestions to the appropriate administrative bodies of the University on any topic relevant to the effective function of the Programme.

3 Student Entry

The Programme of Graduate Studies accepts applications by Degree or Diploma graduates, or senior students about to graduate, from Undergraduate Programmes related to Computer Science and Engineering, from Departments of tertiary education Academic Institutions (University, Polytechnic, Technical University) in Greece, or certified equivalent institutions abroad. The maximum number of accepted students into the Graduate Programme is set to a hundred (100) students per year.

3.1 Application Process

Applications are filled on a specific series of forms available at the Secretariat of Graduate Studies of the Department and at the Departments webpage. For an application form to be considered complete and advance to the evaluation stage, it must be accompanied by:

(1) Official Transcripts.
(2) Copies of Degrees.
(3) Copies of English Language degrees or certifications.
(4) Copies of previous academic work or publications or extensive summaries.
(5) Curriculum Vitae of the applicant.
(6) A Statement of personal goals and professional interests.
(7) At least three letters of recommendation. Recommendation letters should be in the specific form included in the application form, and should be sent directly to the Department by their authors, by post or electronically. Recommendation letters are confidential and are not disclosed by the Department to the applicants under any circumstance, either before or after their possible acceptance.
(8) Any additional information that the applicants consider helpful in their complete evaluation of their application.
(9) If the application is accepted, submission of certified copies of all degrees, recognition certificates, and other official documents, is a prerequisite for enrollment in the Programme.

3.2 Deadlines

The Department has two application cut-off dates per year for applications of entry into the Programme. One during the Fall semester for enrollment during the following Spring semester, and one during the Spring semester for enrollment during the following Fall semester. All applications must be submitted within the corresponding deadlines for each period, as follows:

Application Period	Fall semester	Spring semester
Application submission	October 31st	March 31st
Announcement of results	December 15th	May 31st
Enrollment	Following Spring semester	Following Fall semester

3.3 Application Process

The application and all related documents must be submitted electronically at https://postgrad.cict.uoc.gr where the applicants need to register as new users, process their application and upload all the related material until the applications submission deadline.

All letters of recommendation must be sent directly by their author at the following email address: admissions@csd.uoc.gr

For more information, applicants can contact the Secretariat of Graduate Studies of the Computer Science Department, also using the email address above.

3.4 Application Evaluation Process

The evaluation of all applications is done by a committee set yearly by the Department Faculty Assembly and consists of members of the Department Faculty. Selection criteria taken into account are the Degree Grade Point Average, grades in courses related to the area of the Programme, the University where the applicant studied, any significant achievements in undergraduate studies, any significant work results in the undergraduate level, the result in an Honors Thesis if applicable, letters of recommendation, use of the English language, personal goals for specialization or research, and any other arguments presented by the applicant in their application.

3.5 Equal Opportunity

The Computer Science Department aims to provide equal opportunities in education and specialization. The Department ensures equal opportunities in entry and completion of graduate studies without discrimination based on gender, race, nationality, religion, or personal condition, according to Greek Law.

3.6 Scholarships

The Department notes that a significant number of accepted students are supported financially during their studies.

Notably, in collaboration with the Foundation for Research and Technology--Hellas, the Department offers a large number of scholarships and assistantships every year to graduate students, in the context of research projects. Moreover, the Department tries to grant a financial award every semester to graduate students that stand out for their academic performance and teaching work.

4 Academic Advisor and Graduate Project Advisor

The Department assigns to every candidate accepted into the Programme, a member of the Faculty as an academic advisor, upon first registration. The role of the academic advisor is to help the candidate adapt to the Programme, select and register for courses, and any academic issue that may occur during their graduate studies. The role of the academic advisor is then transferred to the Graduate Project Advisor. The student must select a Graduate Project Advisor until the end of their second (2nd) semester in the Programme, otherwise they will not be able to register for the 3rd semester. The Advisor is assigned by the Faculty Assembly, which decides taking into account (a) the Law regarding the Graduate Project Advisor (b) the application of the student to the Committee of Graduate Studies and (c) the capacity of the Department, towards ensuring the quality of the Programme.

5 Language of teaching and graduate project

Courses can be taught in English. The Graduate Project undertaken and written in English.

6 Physical Presence

Every semester, students declare to the Secretariat whether they will register or ask for a suspension of studies for the upcoming semester, according to set deadlines. Students that register are included in educational and research activities of the Department. Regular presence and participation of the candidates in the activities set by this regulation is mandatory. Registered students are allowed to have a reduced presence during the semester only in the context of activities that are part of their studies (e.g., internships, visits to collaborating institutions, conferences), with the agreement of their Academic Advisor and after approval of the Faculty Assembly.

7 Requirements for acquiring a Diploma of Graduate Studies

Every candidate must select a thematic area in which they will undertake their graduate project. Studies in the Programme require successful completion by the candidates of a series of requirements, related to basic knowledge, graduate courses, teaching assistant work, research assistant work, and other activities. Requirements for being granted an MSc are:

(1) Fulfillment of the basic knowledge requirements

(2) Completion of 120 ECTS, as follows:

- Completion of 42 ECTS from successful completion or transfer of courses. Of all credits, at least 12 ECTS must come from courses in the selected thematic area. In the case of a second thematic area, the candidate must accumulate an additional 12 ECTS from the second area. It is suggested for the candidate to complete all their course obligations during the first two (2) semesters of the Programme.
- Completion of at least 18 ECTS from Special Thematic Activities.
- Completion of 15 ECTS from bibliographic research into the selected thematic area.
- Completion of 15 ECTS from the evaluation of the research direction and dissertation proposal.
- Completion of 30 ECTS from the undertaking and writing of a graduate project, as described below.

(3) Completion of the time requirements for studentship in the Programme.

If the candidate does not satisfy some of the above requirements a diploma is not granted and they are removed from the Programme.

7.1 Requirement of Basic Knowledge

Every candidate must complete the following requirements of basic knowledge based on the thematic area they select in the Programme:

		AREAS											
		A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4
COURSES	CS-150 or CS-100	*	*	*	*	*	*	*	*	*	*	*	*
	CS-240	*	*	*	*	*	*	*	*	*	*	*	*
	CS-119								*		*	*	*
	CS-217									*			
	CS-225	*											
	CS-280					*							
	CS-335				*								
	CS-340							*					
	CS-345		*	*									
	CS-360						*						
	CS-380	*	*	*	*	*	*	*	*	*	*	*	*
	CS-209 (English IV)	*	*	*	*	*	*	*	*	*	*	*	*

Fulfillment of basic knowledge requirements can occur by using course credits of the candidate's undergraduate programme equivalent with the Department's courses listed above, or by registering and completing these undergraduate courses. Students that select two thematic areas should cover the requirements of both areas in basic knowledge. Fluency in the English language is also required.

7.2 Courses

Every semester, all offered graduate courses are listed on the Department's webpage, http://www.csd.uoc.gr. Course credits corresponding to required effort are expressed using the European Credit Transfer System (ECTS). The academic year lasts for two semesters. Each semester has a duration of 13 weeks. Starting and ending dates for each semester are set in the academic calendar of the University of Crete, which is announced before the start of the academic year. All course obligations, including performing and delivering exercises and projects, must have been completed within the duration of each semester, based on the academic calendar. The attendance to lectures is performed by physical presence.

A typical graduate course includes 13 weeks of lectures, corresponding to 6 ECTS and 6 hours of lectures per week, depending on the total effort required by the course. Teaching assignments for graduate courses occur every year by decision of the Faculty Assembly of the Department after a proposal by the Director of the Graduate Programme and the Committee of Graduate Studies. Rescheduling of lost teaching hours occurs by decision of the instructor; in the case of a long pause in teaching, due to special circumstances, rescheduling of lost lectures is decided by the Faculty Assembly of the Department.

Near the end of each semester, courses and instructors are evaluated by the graduate students, using the online course evaluation system of the Quality Assurance Unit of the University of Crete.

At the start of every semester and before a set deadline, each graduate student registers with the Department. During registration graduate students register for courses they will take as well as the rest of their obligations, including teaching or research assistant work, which they will undertake in this semester within the Programme, with the approval of their Academic Advisor or their Graduate Project Advisor. Total workload per semester should not exceed 42 ECTS. Later during the semester, and within a deadline set by the Secretariat of Graduate Studies and with approval from the Academic Advisor or Graduate Project Advisor, students have the option to drop courses for which they have registered. During the registration period, students have the option to request a suspension of studies for the upcoming semester. Applications for suspending study in the Programme have to be explained adequately and approved by the Faculty Assembly of the Department.

Graduate courses are taught in English. The content and the way of examination for each course is set by the instructor, with the agreement of the Committee of Graduate Studies and the approval of the Faculty Assembly. Grading occurs

using a scale between 0 and 10, in increments of 0.5. Grade point averages are computed using weights proportional to the course credits. Student performance is considered adequate if they are awarded a grade of at least six (6 out of 10) on every course, and a grade point average of at least seven and a half (7.5 out of 10). Grades below adequate remain logged in internal records of the Department but are not calculated in the grade point average, nor are these courses counted towards the fulfillment of the Graduate Programme obligations.

A representative list of the graduate courses of the Graduate Programme is shown below:

Code	Course Name	ECTS	Thematic Area
CS-523	Digital Systems CAD Laboratory	6	A1
CS-527	Parallel Computer Architecture	6	A1, A2
CS-529	Multicore Architecture Programming	6	A2, B1, B3
CS-531	Topics in Information theory	6	B2, B4
CS-533	Introduction to Research on Computer Networks	6	A3, A4
CS-534	Packet Switch Architecture	6	A1, A4
CS-539	Advanced Topics on Wireless Networks and Mobile Systems	6	A4
CS-540	Advanced Topics in Programming Languages Development	6	B1, B3
CS-541	Wireless Sensor Networks	6	C1
CS-543	Software Systems and Technologies for Big Data Applications	6	B2, B4
CS-546	Types and Programming Languages	6	A2, B1, B3
CS-548	Cloud-native Software Architectures	6	A2
CS-553	Interactive Computer Graphics	6	C3
CS-558	Internet Technologies and Systems	6	A3, A4
CS-559	Infrastructure Technologies for Large-Scale Service-Oriented Systems	6	A2, A3, B2
CS-561	Web Data Management	6	B2
CS-562	Advanced Database Topics	6	B2
CS-563	Advanced Topics in Information Retrieval Systems	6	B2, B4
CS-565	Process Management Systems	6	A3, A4, B1
CS-567	Knowledge Representation and Reasoning	6	B2, B4

CS-569	Human-Computer Confluence	6	C3
CS-570	Statistical Signal Processing	6	B4, C1, C2
CS-573	Optimization Methods	6	B4, C2
CS-575	Robotic Navigation Laboratory	6	C2
CS-577	Machine Learning	6	B4, C1, C2, C4
CS-578	Voice Processing	6	C1
CS-580	Topics in Algorithm Design	6	B1, C4
CS-583	Graph Algorithms	6	B1, C4
CS-586	Distributed Computing	6	A3, B1
CS-587	Neural Networks and Learning of Hierarchical Representation	6	B4, C1, C2, C4
CS-588	Brain Network Analysis and Modeling	6	B4, C4
CS-590.45	Modern Topics in Scalable Storage Systems	6	A3, B2
CS-647	Modern Storage Systems	6	A2, B2
CS-672	Advanced Topics in Computational Vision	6	B4, C2, C3
CS-673	Introduction to Deep Generative Modelling	6	B4, C2
CS-693	Introduction to Game Theory	6	B1, B4

An indicative schedule is show below:

First Semester		**Second Semester**	
Courses	ECTS	Courses	ECTS
Graduate Courses	18	Graduate Courses	24
CS-508 Technical Writing in English	4	Thematic Activities	6
Thematic Activities	8		
TOTAL	**30**	**TOTAL**	**30**

Third Semester		**Fourth Semester**	
Courses	ECTS	Courses	ECTS
CS-697 Bibliographic Survey	15	CS-699 Research for M.Sc. Thesis	30
CS-698 Assessment of Research Direction and Development of a Research Plan	15		

TOTAL	**30**	**TOTAL**	**30**

Changes in the course schedule and reorganization of courses in semesters may occur by decision of the Faculty Assembly of the Department. The Graduate Programme offers the option of a MSc degree in two thematic areas, if the candidate wishes; in that case course requirements must fulfil both thematic areas.

7.3 Teaching assistant work

Teaching assistant work includes all related duties (usually, student oversight during labs, occasional tutoring classes, etc.) which are assigned by the Department within the conduct of courses, exams, and all educational processes. Teaching assistant work is mandatory for all semesters of the Graduate Programme during which the student is registered in the Programme. Sanctions and penalties in the case of inadequate performance of duties are decided by the Faculty Assembly of the Department.

7.4 Other Thematic Activities

Apart from graduate courses, students of the Graduate Programme must participate in the following activities and fulfil related obligations:

Code	Thematic Activity	Participation	ECTS
HY-6xx	Research Seminars	Optional	3
HY-7xx	Seminar Courses	Optional	3
HY-500	Introduction to Research	Mandatory	2
HY-508	Technical Writing in English	Mandatory	4
HY-690.1	Teaching Assistantship	Mandatory	3
HY-690.2			3
HY-690.3			3
HY-690.4			3
HY-695	Supervised Personal Study	Optional	3
HY-697	Bibliographic Survey	Mandatory	15
HY-698	Assessment of Research Direction and Development of a Research Plan	Mandatory	15
HY-699	Research for M.Sc. Thesis	Mandatory	30

Seminar courses (HY-7xx) are offered by the Department on occasion and are an opportunity for graduate students to get to know the state of the art in various areas.

7.5 Implementation, Examination, and Submission of the Graduate Project

The Graduate Project may focus on research or development. Graduate Project is carried out under the supervision and guidance of the Graduate Project Advisor. Direct supervision and guidance of the Project may be assigned to a third person, holder of a Doctorate Degree, not a member of the Faculty of the Department, but the Advisor maintains responsibility for the progress of the Project.

The examination of the Graduate Thesis adheres to the process below:

- The candidate must be a registered student of the Programme during the semester in which they present their M.Sc. Thesis, delivers the final text, and completes all obligations for the Programme.
- The M.Sc. Thesis is evaluated by an Examination Committee. The Examination Committee is set at the latest 30 days before the date of examination, by initiative of the candidate and in coordination with the Graduate Project Advisor. The Examination Committee consists of three (3) members, or four (4) members if the Supervisor differs from the Graduate Project Advisor, as follows: The Graduate Project Advisor, the Supervisor if different from the Advisor, and a member of the Faculty of the Department in an affiliated area. The remaining two members can be members of the Faculty of the Department or a different University of Greece or abroad, or Researchers of a recognized Research Institution in Greece or abroad. The composition of the Examination Committee is approved by the General Assembly of the Department, which selects a member of the Examination Committee, other than the Supervisor and Graduate Project Advisor, as the coordinator of the formal process of the examination.
- The candidate delivers the text of the M.Sc. Thesis to the members of the Examination Committee at the latest fifteen (15) days before the date of the examination.
- The examination of a M.Sc. Thesis examines both the content and the presentation of the work. The Examination Committee decides independently for the success or failure of the examination with respect to (a) the presentation of the work and (b) the content of the M.Sc. Thesis. The candidate must succeed in both for the examination to be considered successful. The examination of the work is oral and open to audience, and follows the process described below, as supervised by the examination coordinator:
  - If the examination is performed remotely by teleconference, the members of the Examination Committee and the candidate connect to the corresponding teleconference.
  - The examination coordinator starts the process by introducing the candidate. If the examination is performed remotely by teleconference, the coordinator asks for consent from the candidate and the Examination Committee members, for each of the following:
    - The temporary recording of the process so that it can be broadcast to an open audience in live streaming; this is necessary for the examination to be performed by teleconference.
    - The permanent recording of the process for archiving at the Department.
    - The possible publication of the presentation in whole or in part for publicity reasons.
  - The candidate presents their work for 30 to 40 minutes
  - One or more rounds of questions by members of the Examination Committee.
  - A round of questions by the audience.
  - The audience leaves the room or the live broadcast of the teleconference stops. The candidate takes questions from the Examination Committee without an audience.
  - The candidate leaves the room or disconnects from the teleconference and the Examination Committee confers and decides the grade of the presented work. The committee judges the presentation and content of the work independently and concludes for two grades. The scale of grading is Excellent (A), Very Good (B), Good (C), Sufficient (D), Insufficient (F). If either the presentation or the content of the work are deemed insufficient, the examination is considered unsuccessful. The Examination Committee marks these grades on the relevant form. The coordinator signs the form and sends it to the Secretariat of Graduate Studies.
  - The Examination Committee announces the result to the candidate.
  - If the examination is successful, the committee members provide any comments regarding the content of the work to the candidate. The candidate must take into account the comments from the Committee in forming the final text of the M.Sc. Thesis. Depending on the form and length of the modifications/improvements, the members of the Examination Committee can ask to review the new text or authorize the Graduate Project Advisor to grant final approval.

- The members of the Examination Committee approve the final text and then sign the accompanying form.

Finally, the candidate delivers two signed copies of the work; one to the Secretariat of Graduate Studies of the Department, and one to the University Library. In case the work has been funded by a scholarship, a third copy must be delivered to the Secretariat of Graduate Studies of the Department, to be sent to the funding institution. The candidate also delivers the final text of the work to the Secretariat in electronic form. Graduate M.Sc. These are filed in the Digital Library of the University of Crete and are posted online on the Department webpage.

7.6 Duration of Studies

The minimum duration for awarding a Graduate Diploma is set to four (4) full-time semesters, in which the candidate is registered to the Programme. The duration may be prolonged by approval of the General Assembly of the Faculty of the Department, by one (1) or two (2) semesters. Between these semesters other activities may be interleaved, such as internships in industry or other universities or research institutions, amounting to a total pause of studies of up to two (2) semesters, after approval by the General Assembly of the Department. In any case, the duration of the Programme including any extension, cannot exceed six (6) semesters plus a special registration for an additional month, from the date of first registration. At the expiration of this duration, there is an automatic deletion from the Programme. The last registration to the Programme may have the form of a special registration of one month, without any obligations for teaching assistant duties. Any application for a pause of studies for a semester must be submitted at least 30 days before the first day of the semester, as defined on the academic calendar of the University.

8 Course Credit Transfers

ECTS credits required by the Programme come mainly from graduate courses offered by the Department, in which the candidate is registered and which they have successfully completed while registered in the Programme. However, it is possible after an application of the interested student and a request by the Committee of Graduate Studies, for the Department to recognize and transfer credit (while defining the equivalent ECTS weight) for certain graduate or advanced undergraduate courses the student has completed in a University during their undergraduate or other graduate studies, towards the completion of the Programme requirements.

For these credit transfers it is necessary to **disallow a double use** of a course, meaning the counting of course credits towards the requirements of more than one (undergraduate or graduate) titles. Specifically, for a course to be able to count for credit transfer, it should be in exceeding of the requirements of the granting of the undergraduate or other graduate title, within which that course was taken and completed. Moreover, the following restrictions apply:

1. At most 24 ECTS can be transferred in this way; these can come from graduate or advanced undergraduate courses. From 12 ECTS of each specialization area, at most 6 ETCS can be covered by credit transfer; the rest must come from courses in the area that the candidate has completed successfully during the Programme.
2. Any application for course credit transfer of all categories, must be submitted during the first semester of studies in the Programme.

9 Programme of Continuous Education

The Programme of Continuous Education (PCE) functions within the Graduate Programme. The goal of the PCE is education on certain areas of Computer Science and Engineering, without, however, leading to granting of a graduate title. Participation in the PCE is certified by a certificate of completion for these courses in which the student completed successfully. The PCE accepts applications by Degree and Diploma holders, or final-year students of Universities in Greece and abroad. Its duration is at most 4 continuous semesters. Students enrolled in the PCE can register for at most five (5) courses. These courses can count towards the fulfillment of requirements for obtaining a graduate title, in the case of a later acceptance into the Graduate Programme. Registration and attendance of courses within the PCE is governed by the Regulation of Graduate Studies.

10 Cooperation with the Foundation for Research and Technology - Hellas

The Programme of Graduate Studies of the Computer Science Department of the University of Crete operates in cooperation with the Institute of Computer Science (FORTH-ICS) of the Foundation for Research and Technology - Hellas (FORTH). This cooperation includes:

(1) Researchers and Scientists from FORTH-ICS can contribute to the teaching of graduate courses.

(2) FORTH-ICS Researchers contribute to the supervision of graduate research projects, after a decision of the Graduate Project Advisor and approval by the General Assembly of the department and FORTH-ICS.

(3) After a request by the Supervisor or Graduate Project Advisor, and after approval by FORTH-ICS, graduate students can access infrastructure and laboratory equipment in FORTH-ICS, where they can perform part or all of their graduate research.

(4) The Department and FORTH-ICS can jointly invite visiting Professors and Researchers from other Universities or Research institutions in Greece and abroad, to offer seminars, lectures, or complete courses, and to collaborate with researchers and graduate students of the Department and FORTH-ICS.

(5) FORTH-ICS offers a number of scholarships to graduate students and funds collaborations of graduate students with other Universities and Research institutions in Greece and abroad.

11 Intellectual Property

For the duration of a student's graduate studies, and within the context of contracts for scholarship funding or internship, the Department and graduate students should take into account and respect their rights and obligations resulting from related contractual agreements, regarding the terms of management, use, access, publication, dissemination, property, and exploitation of intellectual property rights, which exist or are created during the graduate studies or internship.

12 Academic Ethics

Students of the Programme must respect and observe the Ethics Code of Conduct of the University. Any involvement of graduate students with activities that create conflicts of interest with duties assigned by the Department are deemed to be against the Code of Conduct, such as for example providing teaching services for pay to other students. Any behavior against the Code of Conduct is examined by the General Assembly of the Department, which decides on appropriate penalties.

13 Ceremony of Graduation and Type of Diploma

The ceremony for awarding Diplomas of Graduate Studies occurs at scheduled ceremonies for awarding Degrees, Graduate Diplomas, and Doctorate Degrees of the Department, three times per year, during the third week of November, the third week of March, and the third week of July. The Diploma of Graduate Studies is accompanied by a Diploma Appendix whose type is common to all Graduate Programmes of the University of Crete, and which has been ratified by the University Senate.

The Diploma has the following appearance:

ΕΛΛΗΝΙΚΗ ΔΗΜΟΚΡΑΤΙΑ
ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΡΗΤΗΣ

ΤΟ ΤΜΗΜΑ ΕΠΙΣΤΗΜΗΣ ΥΠΟΛΟΓΙΣΤΩΝ

ΤΗΣ ΣΧΟΛΗΣ ΘΕΤΙΚΩΝ ΚΑΙ ΤΕΧΝΟΛΟΓΙΚΩΝ ΕΠΙΣΤΗΜΩΝ

ΑΠΟΝΕΜΕΙ

ΜΕΤΑΠΤΥΧΙΑΚΟ ΔΙΠΛΩΜΑ ΕΙΔΙΚΕΥΣΗΣ

ΣΤΗΝ

ΕΠΙΣΤΗΜΗ ΚΑΙ ΜΗΧΑΝΙΚΗ ΥΠΟΛΟΓΙΣΤΩΝ

ΜΕ ΤΑ ΔΙΚΑΙΩΜΑΤΑ ΚΑΙ ΤΙΣ ΥΠΟΧΡΕΩΣΕΙΣ ΠΟΥ ΤΟ ΣΥΝΟΔΕΥΟΥΝ

ΣΤΟΝ/ΣΤΗΝ

ΟΝΟΜΑ - ΕΠΩΝΥΜΟ

Ο/Η ΟΠΟΙΟΣ/Α ΑΝΤΑΠΟΚΡΙΘΗΚΕ ΣΤΙΣ ΑΠΑΙΤΗΣΕΙΣ

ΤΟΥ ΠΡΟΓΡΑΜΜΑΤΟΣ ΜΕΤΑΠΤΥΧΙΑΚΩΝ ΣΠΟΥΔΩΝ ΤΟΥ ΤΜΗΜΑΤΟΣ ΤΗΣ

ΗΡΑΚΛΕΙΟ, ημέρα μήνας έτος

Ο ΠΡΥΤΑΝΗΣ

ΟΝΟΜΑ - ΕΠΩΝΥΜΟ

Ο ΠΡΟΕΔΡΟΣ ΤΟΥ ΤΜΗΜΑΤΟΣ

ΟΝΟΜΑ - ΕΠΩΝΥΜΟ

Η ΓΡΑΜΜΑΤΕΑΣ ΤΟΥ ΤΜΗΜΑΤΟΣ

ΟΝΟΜΑ - ΕΠΩΝΥΜΟ

14 Content of Graduate Courses

Graduate courses offered within the Programme are described below. They are courses with scheduled weekly lectures, exercises, homeworks, projects, midterm and final exams, and grades. The content of graduate courses can vary from year to year, depending on the interests of the instructors and students at the time. The following summaries correspond to the most recent version.

CS-523	**"Digital Systems CAD Laboratory"**
Thematic area:	A1
Prerequisites:	CS-220, CS-225
ECTS:	6
Web page:	http://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=gr&course=240

Description:	Electronic design automation (EDA flows) of digital systems and related computer aided design (CAD tools). Hardware description languages (Verilog, VHDL): repetition and deepening. Behavioral level models and structural level models. Simulation: algorithms and tools. Timing analysis. Design verification: test inputs, verify outputs, simultaneously simulate multiple models at different levels of abstraction. Controlling digital systems and designing for controllability. Composable descriptions and automatic material synthesis (eg Synopsys). Component placement and link routing: tools and techniques. Iterative design improvement (back-annotation, ECO, LVS). Examples in FPGA and ASIC technologies. Use of ready-made cores (IP cores), systems on a chip (SoC). Workshop on complete (collaborative) design and verification of a moderately complex digital system, using the taught tools and for multiple target technologies (FPGA and ASIC).

CS-527	**"Parallel Computer Architecture"**
Thematic area:	A1, A2
Prerequisites:	CS-345, CS-425
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy527
Description:	This course discusses the design, implementation, and evaluation of parallel computer architectures. Topics include: Shared address space and message passing programming paradigms, interactions between parallel programs and the underlying architecture, design and implementation of small and large-scale shared memory and message passing multiprocessors, issues in network interface design and scalable interconnection networks, clusters of workstations, performance evaluation.

CS-529	**" Multicore Architecture Programming "**
Thematic area:	A2, B1, B3
Prerequisites:	CS-345, CS-425
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy529
Description:	The aim of the course is to introduce and familiarize the student with languages, libraries, methods and techniques of parallel programming in systems based on multi-core processors. Both the interface of the aforementioned tools with the programmer and their implementation in real systems are studied. The course emphasizes new parallel programming methods aimed at improving system performance, as well as improving programmer productivity, and focuses on the organizational characteristics of multicore architectures that differ substantially from the corresponding characteristics of conventional shared or distributed memory parallel architectures. Students understand the concepts of task sharing and routing between cores, implicit and explicit communication between cores, locality of data access, and synchronization as they are revised and adapted to the new multi-core processors with homogeneous and heterogeneous cores (GPUs, Cell, etc.). In addition, students become familiar both with the interconnection system and with the implementation of new parallel programming methods, such as, for example, programming with transactions (transactions), programming with data flows (streams) and programming with explicit management of the memory hierarchy. The course overviews modern multi-core architectures and categorizes them based on core architecture and homogeneity, memory hierarchy, and communication and synchronization mechanisms. This is followed by a study of programming models for homogeneous common architectures (OpenMP, Intel STM, Intel TBB), heterogeneous architectures (Sequoia, StarSs, RapidMind, CUDA) and architecture-independent models (MapReduce, Merge). Finally, methods of source code translation and implementation of the runtime systems of the above programming models are studied.

CS-531	**" Topics in Information theory "**
Thematic area:	B2, B4
Prerequisites:	-----

ECTS:	6
Web page:	http://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=gr&course=134
Description:	1. Entropy, Relative Entropy, and Mutual Information 2. Asymptotic Equipartition Property 3. Data Compression 4. Channel Capacity 5. Differential Entropy 6. Gaussian Channel 7. Rate Distortion Theory 8. Universal Source Coding 9. Network Information Theory ● Gaussian Multiple-User Channels ● Multiple-Access Channel ● Encoding of Correlated Sources ● Broadcast Channel ● Relay Channel ● Source Coding with Side Information 10. Network Coding Theory 11. Scaling laws for wireless networks

CS-533	**" Introduction to Research on Computer Networks "**
Thematic area:	A3, A4
Prerequisites:	CS-335
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy533
Description:	HY-533 is a seminar course in the area of Computer Networks, which will focus on Security issues, Privacy, and Intelligence on the Internet. Specifically, the course will cover security issues faced by Internet Service Providers, the trends to address such problems by using Software Defined Network (SDN) technologies that make computer networks Smarter and finally, trends related to Data Transparency for Internet users.Also, during the course the design thinking methodology will be used, which provides a series of steps to systematically address a challenge related to the course's literature and aims to promote innovation. In every team of students a mentor will be assigned. Finally, the objective of the course is that students are able to work together in teams and communicate effectively, both in writing and orally. For this purpose, there will be 3-4 lectures on the topics: 1) How to present research in an effective way? 2) How to write a scientific article? And 3) How can one work effectively in a team?

CS-534	**" Packet Switch Architecture "**
Thematic area:	A1, A4
Prerequisites:	CS-225, CS-335
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy534
Description:	1.Entropy, Relative Entropy, and Mutual Information 2.Asymptotic Equipartition Property 3.Data Compression 4.Channel Capacity 5.Differential Entropy

	6.Gaussian Channel 7.Rate Distortion Theory 8.Universal Source Coding 9.Network Information Theory a.Gaussian Multiple-User Channels b.Multiple-Access Channel c.Encoding of Correlated Sources d.Broadcast Channel e.Relay Channel f.Source Coding with Side Information 10.Network Coding Theory 11.Scaling laws for wireless networks

CS-539	**"Advanced Topics on Wireless Networks and Mobile Systems"**
Thematic area:	A4
Prerequisites:	CS-335, CS-345
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy539
Description:	The graduate course HY-539 deals with the extensive study of the concepts and techniques involved with the contemporary research challenges of wireless networks and mobile computing and systems. Students will experiment with new technology, new prototype applications and systems and will be actively involved in research topics. Design and implementation of systems, and evaluation of mobile network applications will be discussed. Topics to be discussed during the course will include: introduction to wireless technology, IEEE802.11, mobile networking, wireless access and information dissemination systems, wireless sensor networks, mobile peer-to-peer systems, location- based applications, routing protocols as well as effective resource management (eg battery, bandwidth) in mobile networks, location-sensing systems, and performance evaluation of wireless networks and their protocols. The objectives of the course are: 1. In-depth understanding of the above subject areas 2. Conducting research and systematically dealing with research topics that mainly include: ● Measurements, analysis, and modeling on wireless networks in order to evaluate their performance and the protocols that support them. ● Design and study of protocols for more efficient use of resources, provision of services with time limitations (real-time services) in wireless networks, location finding, information dissemination in mobile networks. 3. Use, experimentation, and familiarization with new technology by developing innovative tasks. 4. Investigate new ideas and applications in the area of wireless networks by assigning assignments throughout the semester. 5. Evaluation and critique of recent research publications.

CS-540	**" Advanced Topics in Programming Languages Development "**
Thematic area:	B1, B3
Prerequisites:	CS-340
ECTS:	6
Web page:	http://csd.uoc.gr/~hy540/
Description:	1. 1. Classes and Inheritance - class-based / object-based inheritance, typed / untyped inheritance, mixin inheritance, classes / prototypes, object protocols, construction / destruction, garbage collection, finalizers. 2. Languages in a language - syntax patterns, grammar emulation, rapid design, semantics implementation. 3. Integrated development environments - circular extensibility, remote deployment, multiple languages, source level

	2.	debugger, code visualizers. 4. Virtual machines - lookup caching, garbage collection, debugger linkage, instruction set design, just-in-time compilation, concurrency support. 1. Metaprogramming - meta-programs, compile-time meta-programming (CTMP), staged languages and runtime code generation, quasi quotes and meta-level shifting. 2. Generic programming - generic algorithms, type parameterization, concepts and constraints, concept lifting, associated types, retroactive modeling. 3. Design patterns - lazy initialization, object recycler, template method, studying patterns for missing language features like State, Decorator, Visitor and Iterator. 4. Self adaptation - autonomic systems, self management, adaptive systems, self reasoning, adaptive dynamic assembly.

CS-541	**" Wireless Sensor Networks "**
Thematic area: Thematic area:	C1
Prerequisites:	CS-335, CS-215
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy541
Description:	Wireless Sensor Networks are an emerging type of networks and a multi-disciplinary field of research and development. Their distinct characteristic from data networks is that their reasoning of existence is to monitor the physical space and provide access to remote or hostile environments, in a cost-effective manner, without the necessity of any previous infrastructure (e.g. LAN, optical fibres, etc). Representative applications fields are related, but not limited to: environmental and wild-life monitoring, industrial control, smart buildings, smart grid and water management, search and rescue applications, modern telemedicine, etc. WSN are therefore a multidisciplinary field that combines signal processing, networking, embedded programming, and data management. CS-541 focuses on the theory, design and development aspects of such networks with the primary objective to provide a spherical introduction to this field, and additionally cover special topics from a signal processing and networking perspective. In a nutshell, CS-541 will cover the following topics: (a) network standards and connectivity / coverage aspects; (b) Distributed signal processing and machine learning; (c) Programming, simulation and data analysis. **Course Syllabus.** Low-power Personal and Body Area Networks, IEFT RPL & uIP standard, Critical Transmission Power and Asymptotic Connectivity, Sensing Coverage in Convex / non-Convex environments, Deterministic and Probabilistic Sensor Deployment, Synchronization / FSP, Bio-inspired networking methods for dense sensor networks. Distributed algorithms for acquisition, storage and processing: Consensus and Gossip algorithms, Distributed Data Compression, Network Coding Schemes. Modelling and Learning of Spatio-temporal data: Compressed Sensing, Sparse Representations, Low Rank Matrix Completion. Localization: dead-reckoning, passive, multimodal. Programming principles with Real-time Operating Systems: tinyOS / nesC, protothreads / Contiki OS, Over-the-air-programming **Practical information.** During the semester you will be assigned 4 homeworks that will combine the theoretical and programming aspects of the material taught. The programming environment will be on MATLAB and C / Java (Contiki / Cooja Emulator). In addition to these homeworks, you will also be assigned on individual or team projects, which will address special topics on WSN (e.g. build a new routing algorithm, perform a set of experimental studies, design etc). Prospective students will also have to present their project to the rest of their classmates in a 15-min time slot.

CS-543	**" Software Systems and Technologies for Big Data Applications "**
Thematic area:	B2, B4
Prerequisites:	CS-360, CS-252, or instructor permission
ECTS:	6
Web page:	https://elearn.uoc.gr/course/info.php?id=896

Description:	• Basic principles of modern big data processing frameworks. • Programming and use of such frameworks depending on the desired functionality: storage, querying, batch processing, graph processing, streaming, deep learning. • Performance optimizations from the use of those frameworks.

CS-546	**" Types and Programming Languages "**
Thematic area:	A2, B1, B3
Prerequisites:	CS-255, CS-280
ECTS:	6
Web page:	http://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=gr&course=234
Description:	CS546 focuses on type systems and their application in the design and implementation of programming languages. The course also explores type system applications in tools that automatically analyze programs and assist programmers, such as compiler optimizers, debuggers, verifiers, analyzers, model checkers, etc.

CS-548	**" Cloud-native Software Architectures "**
Thematic area:	A2
Prerequisites:	CS-335, CS-345
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy548
Description:	The Internet provides services to billions of users worldwide. News sites, social media networks, e-shops, government agencies, and so on, must be online around the clock, no matter the load. As such, contemporary Internet-scale applications are deployed in the Cloud. Their internal architectures have evolved into complex webs of "microservices", physically dispersed around the globe, using virtualized resources and software components supplied by the cloud providers. In this course we explore the structure of large-scale Internet services and focus on the techniques and tools used to build and deploy modern-day applications in cloud platforms, including containers and "serverless" functions. Through a series of hands-on sessions and assignments students are guided into mastering the advanced usage and understanding the working internals of Kubernetes, which has become the de facto standard for abstract, cross-cloud service composition. Additionally, we expand on how Kubernetes is actually used by big cloud providers, such as Amazon and Google, and how deployed container-based microservice architectures can utilize respective supporting services and APIs to achieve uninterrupted operation at a global-scale.

CS-553	**" Interactive Computer Graphics"**
Thematic area:	C3
Prerequisites:	CS-358
ECTS:	6
Web page:	http://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=gr&course=140
Description:	The aim of this advanced computer graphics course is to explore the algorithms and methods used for modern interactive graphics: when computerized images need to be displayed at many frames per second utilizing hardware acceleration. The focus is to introduce students to state--of--the--art graphics technology (GPU programming) and latest techniques for modeling, rendering and animation that enable

	interactive applications like game engines and real--time 3D simulations.

CS-558	"Internet Technologies and Systems"
Thematic area:	A3, A4
Prerequisites:	CS-345
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy558/
Description:	This course deals with Internet Systems and Technologies. The main focus is to present important technologies as well as changes needed in operating systems and run-time systems in order to support these technologies. The students will need to make a paper presentation, a project consisting of a written report.

CS-559	"Infrastructure Technologies for Large-Scale Service-Oriented Systems"
Thematic area:	A2, A3, B2
Prerequisites:	CS-345, CS-360
ECTS:	6
Web page:	https://www.csd.uoc.gr/~hy559/
Description:	The explosive growth of e-services in recent years has created the need to design, implement, and manage infrastructures that support large-scale service-based systems. The course offers an introduction to the scalable infrastructure technologies designed to support large-scale e-services. In the course we will examine existing design techniques and research problems in the design and implementation of these systems as well as their possible solutions. The course focuses on large-scale service-oriented systems and their architectures; design principles for scalable high performance; management of infrastructural service-level agreements (SLAs); information lifecycle management;; design optimization to meet application requirements; the role of the human factor in service engagements; service delivery models; and several case studies (Amazon, Google, Yahoo, Facebook). This course is targeted for graduate students and advanced undergraduates and requires the undertaking of a research project. The topics of the research projects will be chosen with the help and guidance of the course staff. Other requirements include two homework assignments, two short in-class quizzes, a midterm exam, and a final exam. **Topics:** • Review of service-oriented architectures and scalable implementation techniques • Review of distributed systems principles • Service-level agreements • Virtualization at different levels (servers, network, storage) • Cloud services and IT outsourcing • Application-specific service systems • The human factor in large scale e-service systems • Information/data/storage lifecycle management • High availability and data reliability • Design and deployment of low cost scalable services

CS-561	" Web Data Management"
Thematic area:	B2
Prerequisites:	CS-460
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy561/index.htm
Description:	The goal of this course is to expose students to advanced topics of web data management with emphasis on data semantics. The Semantic Web is an evolving extension of the WWW where the content can be expressed not only in natural language (as in the classical Web of documents), but also in formal languages (e.g. RDF/S, OWL) that can be read and used by software agents, permitting them to find, share and integrate information more easily. For achieving the Semantic Web vision, the recent years several technologies have been emerged, many of them are international (W3C) standards. These technologies include: knowledge representation languages (e.g. RDF/S, OWL) and formats for exchanging knowledge, query languages (π.χ. SPARQL), rule languages and inference engines, techniques for constructing mappings for integrating/harmonizing schemas and data, technologies for mining structured knowledge from texts. Moreover the current trend of publishing Linked Data is based these technologies. This course will allow the students to understand the overall vision, get acquainted with the current technology stack, use these technologies, and connect up with the related current research. Moreover, at the end of this course the students should have the skills to define and test ontologies, formulate SPARQL queries, define schema mappings, formulate rules for instance matching and use tools for semantic data management.

CS-562	" Advanced Database Topics"
Thematic area:	B2
Prerequisites:	CS-360
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy562
Description:	The course deals with subjects such as treatment and optimisation of queries in relational data bases, distributed systems of data bases, object oriented data bases, as well as newer subjects such as unification of data bases, and Mobile data bases.

CS-563	" Advanced Topics in Information Retrieval Systems"
Thematic area:	B2, B4
Prerequisites:	CS-463
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy563
Description:	This course focuses on modern and advanced topics in Information Retrieval, specifically on: • **(A) Natural Language Processing** Connection to Linguistics, Pre-processing, morphological, syntactical, semantic and pragmatic analysis. • **(B) Question Answering Systems** Typology of QA systems, techniques for question answering and dialogue systems over documents and data • **(C) Machine Learning Techniques in Information Retrieval** Word Embeddings, Learning to Rank • **(D) Techniques for Sentiment and Opinion Mining, Bias and Fairness in Information Access** Opinion Retrieval, Opinion Analysis, Related Evaluation Activities, Fairness, Diversity/Coverage/Novelty • **(E) Evaluation of Interactive Information Retrieval** Methods, metrics, collections, statistical significance

CS-565	" Process Management Systems"
Prerequisites:	A3, A4, B1
Prerequisites:	CS-360
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy565/
Description:	The course deals with the workflow technology which represents the basic framework for the development of large scale business management systems. Starting from abstract descriptions of business processes the course will examine modeling, design, analysis, development and verification methods of the processes. Afterwards the course will study the management of implemented business processes using the workflow systems technology. The organisation and architecture of workflow management systems will be examined under the emergence of recent trends in the research fields of e/web-services and web-based information systems.

CS-567	" Knowledge Representation and Reasoning"
Thematic area:	B2, B4
Prerequisites:	HY-380, HY-387
ECTS:	6
Web page:	http://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=gr&course=150
Description:	The course deals with the workflow technology which represents the basic framework for the development of large scale business management systems. Starting from abstract descriptions of business processes the course will examine modeling, design, analysis, development and verification methods of the processes. Afterwards the course will study the management of implemented business processes using the workflow systems technology. The organisation and architecture of workflow management systems will be examined under the emergence of recent trends in the research fields of e/web-services and web-based information systems.

CS-569	"Human – Computer Confluence"
Thematic area:	C3
Prerequisites:	CS-364 (CS-359, CS-469)
ECTS:	6
Web page:	http://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=gr&course=236
Description:	The postgraduate course **Human-Computer Confluence**, includes material addressing contemporary issues of interaction between the Humans and the Distributed, "Invisible" and "Smart" Computational Environment, where the need for better "synergy", "symbiosis" and "coexistence" emerges. The main feature of the course is to highlight and elaborate on the progressive paradigm shift from human – computer interaction to human – computer confluence. This course focuses on the following topics: • Contemporary Interaction Techniques. • Context of Use in Smart Environments. • Smart Objects and the Internet of Things. • Interaction Design for Intelligent Environments. • Extended Reality Technologies. • Programming Intelligent Environments. • Digital accessibility in Intelligent Environments. • Interaction related psycho-physiological issues.

	• Human behavior & human activity understanding and visualization. • Interaction in Smart City Environments. • Natural interaction with physical objects in intelligent environments. • Ambient Assisted Living. • Future Trends.

CS-570	**" Statistical Signal Processing"**
Thematic area:	B4, C1, C2
Prerequisites:	CS-370, CS-217
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy570
Description:	This course focuses on problems, algorithms, and solutions for processing signals in a manner that is responsive to a changing environment. Adaptive signal processing systems are developed which take advantage of the statistical properties of the received signals. The course analyzes the performance of adaptive filters and considers the application of the theory to a variety of practical problems such as interference and echo cancellation, signal and system identification, and channel equalization. The class is designed as an advanced statistical signal processing course in which students will build a strong foundation in approaching problems in such diverse areas as acoustic, sonar, radar, geophysical, biomedical, and communications signal processing. Understanding of the theoretical foundations of statistical and adaptive signal processing theory will be achieved through a combination of theoretical and computer-based homework assignments. Course Outline: PART I: BACKGROUND MATERIAL AND LINEAR OPTIMUM FILTERING Topic 1: Background MaterialAdaptive filtering: Concepts and applicationsDiscrete-time signal processingStationary processes and modelsSpectrum analysisLinear algebra: Eigenanalysis and matrix decompositions Topic 2: Wiener FilteringMinimum mean square error (MMSE) and the orthogonality principleDigital Wiener filter and Wiener-Hopf equationsConstrained linear MMSE estimationApplications: Minimum variance beamforming Topic 3: Linear PredictionForward and backward predictionLevinson-Durbin algorithmLattice filtersApplications: DPCM speech coding PART II: ADAPTIVE FILTERING METHODS Topic 4: Stochastic MethodsSteepest Descent algorithmLeast-Mean-Square (LMS) algorithmProperties of the LMSNormalized and frequency-domain LMSGradient adaptive lattice methodsRecursive LMS (RLMS) for adaptive IIR filteringApplications: Active noise control and echo-cancellation Topic 5: Least Squares MethodsLeast squares and orthogonalityRecursive least squares adaptive algorithmsProperties of RLSApplications: ADPCM speech encoding

CS-573	**" Optimization Methods"**
Thematic area:	B4, C2
Prerequisites:	CS-110, CS-119, CS-380 (CS-217, CS-471)
ECTS:	6
Web page:	http://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=gr&course=152
Description:	Optimization algorithms are a very powerful and flexible mathematical tool that can be used to model a very wide range of problems. For this reason, these algorithms are currently applied to many fields of computer science and applied mathematics. This course will look at a series of modern techniques of this kind, covering a wide range of topics such as discrete optimization and convex programming. The aim in both cases will be to present a modern view of the basic principles and ideas on which the optimization algorithms are based, as well as to look at modern and interesting applications from different domains in order to understand how these algorithms are applied in practice. Emphasis will also be placed on the computational cost of the relevant algorithms, as the problems encountered in practice are generally of quite large scale.

CS-575	" Robotic Navigation Laboratory"
Thematic area:	C2
Prerequisites::	CS-475
ECTS:	6
Web page:	http://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=gr&course=154
Description:	HY-575 follows HY-475 with the aim of practical training in topics studied in HY-475. As such, it includes the development, experimentation, and evaluation of sensor data analysis methods, robot motion programming, robot control, and general issues related to the navigation of robotic systems. To achieve the objectives of the course, laboratory robotic systems are used.

CS-577	" Machine Learning"
Thematic area:	B4, C1, C2, C4
Prerequisites:	CS-150, CS-217, CS-380
ECTS:	6
Web page:	https://elearn.uoc.gr/
Description:	The purpose of the course is to provide a broad introduction to the field of Machine Learning including the basic theory, principles, and algorithms, as well as practical applications on real problems. The topics focus on supervised classification and include: (1) A brief reminder of basic probabilities. Statistical testing of hypotheses.(2) Supervised learning and learning from examples. Hypotheses space, algorithms for learning predictive and diagnostic models and classification models (Decision Trees, Random Forests, Support Vector Machines, Artificial Neural Networks, Naive Bayes, K-Nearest Neighbors)(3) Metrics for measuring performance and the Area Under the Receiver's Operating Characteristic Curve.(4) Estimation of predictive performance and accuracy, theory and algorithms for model selection, overfitting, and practical applications of machine learning(5) Algorithms for variables (feature) selection(6) Bayesian Networks and learning of causal relations and structures.

CS-578	" Voice Processing"
Thematic area:	C1
Prerequisites:	CS-370
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy578
Description:	Discrete Time Signal Processing FrameworkProduction and Classification of Speech SoundsAcoustics of Speech ProductionLinear Prediction: analysis, synthesis, and modifications of speechAutocorrelation methodCovariance methodGlottal signal modelsInverse filteringSinusoidal Models: analysis, synthesis, and modifications of speechSinusoidal ModelHarmonic ModelAdaptive Sinusoidal ModelsSpeech TransformationsTime scalingPitch scalingSpeech CodingCoding schemesScalar quantizationVector quantizationSpeech EnhancementSpectral SubtractionWiener FilterSpeech Intelligibility EnhancementSpectral ShapingDynamic Range CompressionSpeaker IdentificationEM algorithmGaussian Mixture ModelsSpeech SynthesisNeural NetworksHidden Markov ModelsLinear Dynamical ModelsMacine Learning techniquesDeep Learning Monthly MATLAB projects on speech processing are mandatory.

CS-580	" Topics in Algorithm Design"
Thematic area:	B1, C4
Prerequisites:	CS-240, CS-280, CS-380
ECTS:	6

Web page:	http://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=gr&course=158
Description:	This lesson gives a full picture of the typical procedure followed for the algorithmic solution of any specific problem - from the first step, up to the last one: (1) defining a problem; (2) discretization and exhaustive search; (3) "good characterizations"; (4) polynomial algorithms vs NP-complete problems; (5) "accelerating" an algorithm; (6) optimal algorithmic solutions. Within this framework the following issues are presented and analyzed: (a) fundamental concepts, e.g. reductions and complexity classes; (b) general algorithmic design techniques like data structures, dynamic programming, parametric search, linear programming et.al.; and (c) analytical techniques, especially techniques for proving the correctness of algorithms.

CS-583	**" Graph Algorithms"**
Thematic area:	B1, C4
Prerequisites:	CS-240, CS-380
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy583
Description:	From apps to graphs. Review of fundamental algorithms for graphs. Optimization algorithms for graphs: flow, mappings, connectivity, routing, Euler paths, Hamilton paths, etc. Planar graphs: binary graphs, planar orientations, planar representations, visibility graphs. Graph visualization: graphs and their design, examples of graph design, divide and conquer techniques for drawing trees and serial-parallel graphs. Flow and orthogonal design, flow and ascending flatness, incremental constructions, non-planar orientations, layered directed graph design, dynocentric methods, circular graph designs, lower bounds, automatic labeling, and various other topics.

CS-586	**" Distributed Computing"**
Thematic area:	A3, B1
Prerequisites:	CS-380
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy586/index.html
Description:	This course focuses on the design and analysis of distributed algorithms for multiprocessors that communicate via a shared memory. It studies fundamental models of distributed computing (to capture the needs of modern distributed applications), as well as major techniques for the design and analysis of distributed data structures and algorithms. The biggest part of the course is devoted to synchronization mechanisms; several different techniques are studied for achieving it. A lot of distributed implementations have been presented in the literature in a very informal way and without any proof of their correctness. As a result, the behavior of many of these algorithms is simply unpredictable. This course aims at providing the required theoretical foundations, without which it is impossible to design correct distributed algorithms, check the correctness of current distributed implementations, capture all the details of their performance, discover their inherent limitations and establish optimality results, or determine whether any design tradeoffs are indeed fundamental or simply artifacts of certain environments. The main objective of the course is to supply the students with all the required dexterities for a rigorous and complete theoretical study of shared-memory multiprocessing systems.This class is geared toward graduate students at all levels as well as advanced undergraduates.

CS-587	**" Neural Networks and Learning of Hierarchical Representation"**
Thematic area:	B4, C1, C2, C4
Prerequisites:	CS-217, CS-119
ECTS:	6

Web page:	http://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=gr&course=161
Description:	The scientific activity of the last decade revealed many new directions and highly successful extensions of Neural Networks towards learning data representations for various perception systems. Representations of this kind are composed of many layers of nonlinear calculations (multilayer architectures) and are based on classic artificial neural networks. In recent years it has become evident that learning such multilayered representations can contribute to a significant improvement in perception systems performance. The purpose of this course is to present an introduction to artificial neural networks and in learning hierarchical representations based on those network structures. The course will focus on architectures, methodologies and algorithms, and will also include laboratory exercises.

CS-588	**" Brain Network Analysis and Modeling"**
Thematic area:	B4, C4
Prerequisites:	CS-217, CS-215, CS-240
ECTS:	6
Web page:	http://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=gr&course=235
Description:	The course's aim is to introduce students to the basic biology of the neocortex and present its functional network architecture. To better illustrate the main issues, the course will focus on the primary visual cortex of the mouse. In the first part of the course, it will overview the principles of brain organization, neurophysiology and biophysics of excitable cells, synaptic transmission, network anatomy and physiology and canonical circuits in mouse neocortex. It will then focus on the multi-neuronal computations. The second part will present graph-theoretical and statistical analysis tools for analyzing functional networks. In the third part of thecourse, experimental methods for probing circuit function using 2 photo imaging, optogenetics, patch clamping in vivo, in vitro will be discussed. An important part of the course, it will be the project identification, discussion, and implementation. During the last week, the students will present their project.

CS-590.45	**" Modern Topics in Scalable Storage Systems"**
Thematic area:	A3, B2
Prerequisites:	CS-345, CS-360
ECTS:	6
Web page:	https://www.csd.uoc.gr/~hy590-45/
Description:	This course offers an introduction to scalable storage systems and examines existing design techniques as well as current research problems in the design and implementation of such systems. The core part of the course focuses on the study of scalable storage systems with special emphasis on architectures, design principles for scalable performance, data reliability, high availability, the management of data during their lifecycle, application-specific design concepts, ways to reduce implementation cost, and quality of service (QoS) techniques. The course requires the undertaking of a research project whose results will be presented by students at the end of the semester. **Topics:** • Introduction to distributed storage systems, file systems, and key-value stores • Introduction to high availability and data reliability techniques • Data replication and the Paxos consensus algorithm • Design of application-specific distributed storage systems • Consistency models for distributed storage systems • Design and implementation of enterprise-scale storage controllers • Data lifecycle management

	• Disconnected operation

CS-647	" Modern Storage Systems"
Thematic area:	A2, B2
Prerequisites:	CS-345
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy647
Description:	This course discusses storage systems with emphasis on the design and implementation of modern key value stores that host the data for big data analytics applications. The course examines the basic axis in the design of key-value stores and covers the path from the point a request is created in a client until the request is served from the storage device in a storage server. While developing the main techniques for key-value stores that have been (and are currently being) proposed, it also discusses the characteristics of more traditional storage systems and future storage trends, especially for device storage technologies. The course includes lectures, research paper reading/discussion, assignments, and a student-proposed projects.

CS-672	" Advanced Topics in Computational Vision"
Thematic area:	B4, C2, C3
Prerequisites:	CS-472
ECTS:	6
Web page:	http://www.csd.uoc.gr/~hy672
Description:	The goal of this course is the in-depth study of selected topics on Computer Vision so that the students that attend it have the necessary background in order to perform research in the area of Computer Vision.The selection of the topics varies in each semester and is determined by the current trends in the computer vision literature, as well as the special interests of the instructor and the students. The selected topics fall in broader areas such as: image acquisition and optical sensors, low level vision algorithms, image and video features, feature grouping and image segmentation, image color and texture, motion perception and object tracking, multi-view geometry, 3D reconstruction, shape representation and object modeling, feature correspondence, object recognition, statistical models and learning method in vision, active vision systems, robotic vision, detection and recognition of faces, gestures and actions, cognitive and biologically inspired vision.

CS-673	"Introduction to Deep Generative Modelling"
Thematic area:	B4, C2
Prerequisites:	CS-217. CS-119
ECTS:	6
Web page:	https://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=en&course=273
Description:	Generative models (GMs) are widely used in many subfields of AI, Machine Learning and Data Science. Recent advances in parameterizing these models using deep neural networks, combined with progress in stochastic optimization methods, have enabled scalable modeling of complex, high-dimensional data. In this course, we will study the probabilistic foundations and learning algorithms for deep generative models, including generative adversarial networks (GANs), variational autoencoders (VAEs), normalizing flows (NFs), deep autoregressive (DAR) models, diffusion probabilistic models (DPMs), and energy-based models (EBMs). The course will also discuss application areas that have benefitted from deep generative models, including speech processing, computer vision, reinforcement learning, and

	inverse problem solving. Demonstrations of deep generative models and code execution will be established. This course includes lectures, research papers, assignments, a student-proposed project and a final exam.

CS-693	" Introduction to Game Theory"
Thematic area:	B1, B4
Prerequisites:	--------
ECTS:	6
Web page:	http://www.csd.uoc.gr/CSD/index.jsp?content=pg_courses_catalog&openmenu=demoAcc4&lang=gr&course=173
Description:	The course is an introduction to game theory, from the most basic concepts to some more advanced ones which can be used to formulate and solve real-world problems which are typical of, e.g., wireless communications, computer science and economics. In particular, we will study the concepts of strategical thinking, rational decision making, payoffs, utility functions, preferences, pure/mixed strategies, dominant strategies, best-response strategies, normal-form games, solution concepts ((approximate) Nash equilibria, Correlated equilibria), examples of games (symmetric bimatrix games, zero-sum games), formulation of zero-sum games via Linear programming and Minimax theorem. We will also discuss algorithms for computing solution concepts (pure Nash equilibrium computation, Lemke-Howson algorithm, algorithms for approximate Nash equilibria, Correlated equilibria via Linear programming), extensive games and backward induction, repeated games, inefficiency of solution concepts (Price of Anarchy, Price of Stability), selfish routing (atomic/non atomic games, Wardrop equilibrium, Braess paradox), mechanism design (First price auctions, Second price auctions), matching theory (Gale-Shapley algorithm). Finally, we will discuss applications of game theory to economical and wireless networking problems.