School of Electrical & Computer Engineering

Graduate Studies Program
2021 - 2022

Chania 2021
1. Introduction

The School of ECE offers high-level engineering education with emphasis in four different areas: Computer Science, Electronics and Computer Architecture, Systems, and Telecommunications. These correspond to the four administrative divisions of the School and represent respective research areas.

The program of graduate studies, which was initiated in 1993, has a research focus; it currently offers M.Sc. and Ph.D. degrees in Electrical and Computer Engineering. A total of 356 M.Sc. and 52 Ph.D. students have graduated from the School of ECE so far. Both degrees require (a) the registration, attendance, and successful examination in graduate courses offered by the school; (b) the completion of a research M.Sc. thesis or an original Ph.D. dissertation under the supervision of a faculty member of the School. The Ph.D. dissertation must represent original research, published in peer-reviewed international journals and conferences.

Most of the faculty members have earned their Ph.D. degrees from top universities around the world and many have pursued careers as tenure track or tenured faculty members abroad before joining the School of ECE. The current high level of scientific activity, peer-reviewed publications, and competitive research funding of the School of ECE are due to the unrelenting efforts and talent of the graduate students and their close collaboration with the faculty of the School, as well as their active involvement in research projects run by the School. The international recognition of ECE is evidenced in the numerous publications in top scientific journals and international conferences, several best paper awards earned from the Institute of Electrical and Electronic Engineers (IEEE) by ECE faculty and student publications (both in journal publications and at international conferences), participation of the faculty in top journal editorial boards and top international conference program committees, etc. The School has demonstrated continuous improvement in academic quality which is due to the continuous efforts of the faculty, staff, and students.

Many students who have graduated with an M.Sc. or Ph.D. degree from the School of ECE currently hold tenured or tenure-track faculty positions at top US and European institutions, research positions at university research labs, national research and industrial development labs, and have founded and run technology spin-offs or work as professional engineers in Greece, Europe, and the USA.

The present Graduate Program Guide provides information about the program of graduate studies in the School of ECE. Further information can be found on the website of School of ECE (www.ece.tuc.gr).
2. Scope and Goals of the Program

The strategic goal of ECE’s graduate program is to enable, sustain, and constantly improve the research conducted by the members of the School, as well as to improve the research and innovation ecosystem of the School and the Technical University of Crete.

Specialization is sought in the following areas:

A. Electronics & Computer Architecture
B. Telecommunications
C. Systems
D. Informatics
E. Applications of Information Society
F. Data analysis including big data
G. Energy
H. Physics
I. Mathematics

The School of ECE actively pursues new and emerging areas of research including the development of novel methodologies for the analysis, storage, and modeling of big data as well as applications of machine and statistical learning methods in practical problems of current interest. In particular, such problems may be motivated by the European priority research areas (Horizon Europe Global Challenges and European Industrial Competitiveness) which include health, culture, creativity and inclusive society, civil security for society, digital economy, industry and space, climate, energy and mobility, food, bioeconomy, and natural resources, agriculture, and environment.
3. Faculty

Dimitris G. Angelakis, Associate Professor

Costas Balas, Professor
Ph.D. University of Patras, Greece, 1992.

Nikolaos Bekiaris-Liberis, Assistant Professor
Diploma National Technical University of Athens, Greece, 2007.
Ph.D. University of California, San Diego, USA, 2013.

Aggelos Bletsas, Professor
Diploma, Aristotle University of Thessaloniki, Greece, 1998.
Ph.D. MIT, USA, 2005.

Matthias Bucher, Associate Professor
Diploma Swiss Federal Institute of Technology–Lausanne, Switzerland, 1993.
Ph.D. Swiss Federal Institute of Technology–Lausanne, Switzerland, 1999.

Georgios Chalkiadakis, Associate Professor
Ph.D. University of Toronto, Canada, 2007.

Stavros Christodoulakis, Professor Emeritus
M.Sc. Queen’s University, Kingston, Canada, 1977.
Ph.D. University of Toronto, Canada, 1981.

Antonis Deligiannakis, Professor
Diploma National Technical University of Athens, Greece, 1999.
Ph.D. University of Maryland, USA, 2005.

Vassilis Digalakis, Professor
Diploma National Technical University of Athens, Greece, 1986.
Ph.D. Boston University, USA, 1992.
Apostolos Dollas, Professor
B.Sc. University of Illinois at Urbana–Champaign, USA, 1982.
Ph.D. University of Illinois at Urbana–Champaign, USA, 1987.

Demosthenes Ellinas, Professor
Ph.D. University of Helsinki, Finland, 1990.

Minos Garofalakis, Professor
Diploma University of Patras, Greece, 1992.

Dionissios Hristopulos, Professor
Diploma National Technical University of Athens, Greece, 1985.

Sotiris Ioannidis, Associate Professor
Ph.D. University of Pennsylvania, USA, 2005.

Fotios Kanellos, Associate Professor
Diploma National Technical University of Athens, Greece, 1998.

George Karystinos, Professor
Diploma University of Patras, Greece, 1997.

Eftichios Koutroulis, Associate Professor
Diploma Technical University of Crete, 1996.

Michail Lagoudakis, Associate Professor
Diploma University of Patras, Greece, 1995.

Athanasios Liavas, Professor
Diploma University of Patras, Greece, 1989.
Ph.D. University of Patras, Greece, 1993.
Katerina Mania, Professor

Daphne Manoussaki, Assistant Professor
Ph.D. University of Washington, Seattle, USA, 1996.

Michael Paterakis, Professor
Diploma National Technical University of Athens, Greece, 1984.
Ph.D. University of Virginia, USA, 1988.

Euripides Petrakis, Professor
Ph.D. University of Crete, Greece, 1993.

Minos Petrakis, Associate Professor
M.Sc. University of Illinois at Urbana-Champaign, 1982.
Ph.D. University of Illinois at Urbana-Champaign, 1987.

Vassilis Samoladas, Associate Professor
Diploma Aristotle University of Thessaloniki, Greece, 1992.
Ph.D. University of Texas at Austin, USA, 2001.

George Stavrakakis, Professor
Diploma National Technical University of Athens, Greece, 1980.

Michael Zervakis, Professor
Diploma Aristotle University of Thessaloniki, Greece, 1983.
Ph.D. University of Toronto, Canada, 1990.
4. Degree Requirements

4.1 Master of Science (M.Sc.)

Three specializations are available, leading to a Master of Science (M.Sc.) in Electrical and Computer Engineering:

Specialization A: Telecommunications, Signal Processing and Automatic Control.

Specialization B: Computer Science and Engineering.

Specialization C: Electronics, Energy and Quantum Systems.

The program has a minimum duration of three academic semesters (90 ECTS) and the M.Sc. students are offered two study options:

Option 1: three 7-ECTS courses plus 69-ECTS thesis.

Option 2: seven 7-ECTS courses plus 41-ECTS thesis.

Coursework is considered completed if the student achieves a grade at least six (out of ten) in each course and the average grade over all courses is at least seven and a half.

For both study options, the M.Sc. students are expected to publish (or report mature research results that can be published) in first class conferences and/or journals. Additional credits from the undergraduate program of School of ECE may be requested for specific M.Sc. applicants who have not received a 5-year undergraduate diploma in Electrical & Computer Engineering (ECE).

Before graduation, the M.Sc. thesis supervisor is expected to submit a brief report, summarizing the thesis contributions.

Public defense of the thesis is mandatory.

The duration of study can be extended up to five academic semesters for full-time graduate students.

The M.Sc. program complies with the provisions of the Greek national law. Applicants who have obtained their Bachelor or Master’s degrees from non-Greek Universities need to have their degrees approved by the National Academic Recognition Center (NARIC) in order to fulfill the graduation requirements from the program.

4.2 Doctor of Philosophy (Ph.D.)

The course load for Ph.D. applicants consists of at least three full-credit courses. Applicants who do not possess M.Sc. or integrated Master’s degrees are required to take at least six full-credit courses. The coursework requires the approval of the academic advisor and should comply with ECE guidelines. Additional credits from the
undergraduate program of School of ECE may be requested for Ph.D. applicants who have not received a 5-year undergraduate diploma in Electrical & Computer Engineering (ECE). The Ph.D. program complies with the provisions of the Greek national law. Applicants who have obtained their Bachelor or Master’s degrees from non-Greek Universities need to have their degrees approved by the National Academic Recognition Center (NARIC) in order to fulfill the graduation requirements of the PhD program.

Ph.D. applicants must also present two lectures which will be open to the entire community. Their progress is closely monitored by a three-member committee, including the advisor.

Before graduation, the Ph.D. thesis supervisor is expected to provide a brief report, summarizing the novel contributions of the thesis.

Public defense of the thesis is mandatory.

The maximum duration of the studies is twelve semesters for applicants without an M.Sc. or eight semesters for applicants with an M.Sc. from the ECE School (or other equivalent M.Sc. program).

Further details can be found at the School’s website.

5. Admission Procedure

Admission opens three times per year, before the beginning of each academic semester and once in mid-summer. The call for applications and the respective deadline are announced at the School’s website.

Applicants must provide three recommendation letters and must have secured a thesis supervisor who must be a faculty member of the School.

Recommendation letters must be uploaded by the application deadline on the online application system. Applicants are advised to make necessary arrangements with supporting recommenders well before the deadlines.

Conditional admission to the graduate program can be granted to students who have not completed all undergraduate program graduation requirements but are close to graduation.

Specifically for Ph.D. applicants, an M.Sc. in a field relevant to Electrical & Computer Engineering is necessary. Such requirement can be waived only for special cases of strong academic merit, according to the provisions of Greek national law.

Further details can be found at the School’s website and in the respective call for applications.
### 6. Courses per Specialization

#### 6.1 Graduate Courses

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### Topics in Advanced Automatic Control

Visualization and Virtual Reality

### 6.2 Cross-listed Graduate Courses

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7. Brief Descriptions of All Graduate Courses

Advanced Computer Architecture (B, C)
Advanced topics in computer architecture: thorough study on architectures that highly exploit instruction level parallelism: super-scalar (with in-order and out-of-order instruction execution), VLIW and EPIC, multi-scalar, multi-threading and simultaneous multi-threading (SMT). Instruction and data flow prediction, analysis on processor partitioning for higher clock frequency and lower power consumption. Network interface integration for processors targeting parallel systems. Advanced topics on cache memories, trace-cache. High performance memory systems and busses, architectural techniques for reducing power consumption. Study and comparison on state-of-the-art high performance processors (case studies).

Advanced Concepts in Machine Learning and Pattern Recognition (A, B)
The course develops on the theoretical underpinnings of machine learning, addressing also issues of explainability in learning. The course provides a broad and detailed consideration of the issues in machine learning, datamining, and statistical pattern recognition. Topics include: Regression and Classification; Image Categorization vs Segmentation; Regularization to prevent overfitting the training data; Neural Networks: Representation & Learning; Associations of Neural with brain networks: Perception, abstraction and detailed recognition; Evaluation of Machine Learning; Machine Learning System Design; Addressing skewed data; Dimensionality Reduction; Anomaly Detection; Large Scale Machine Learning vs Transfer Learning.

Advanced Topics in Convex Optimization (A)
The course covers advanced topics in convex optimization and the material may change. Topics that are usually covered include: information complexity of black box models for (convex) optimization problems, subgradient method, optimal first – order methods for convex optimization, accelerated gradient, proximal operator and proximal method, Projections onto convex sets, (Block) Coordinate Descent method, Alternating Direction Method of Multipliers, Stochastic gradient.

Advanced Topics in Time Series Analysis with R (A, B, C)
Introduction to the R Programming Environment, Review of basic concepts in time series analysis, ARMA(p,q) Models, SARIMA models for time series with complex trends and periodicities, Nonlinear auto-regressive, conditionally heteroskedastic models (ARCH/GARCH), Parameter estimation (method Cochrane/Orcutt, methods of generalized least squares and maximum likelihood) , Optimal model selection and residual analysis, Cross validation methodologies, Forecasting methodologies (for stationary time series, time series with trends and periodicities, exponentially weighted smoothing), Analysis of multivariate time series, Estimation of cross-covariance function, Transfer function models, Pre-whitening transformations, Nonlinear time series analysis with dynamical systems theory.
Advanced Image Processing (A, C)
This course develops on advanced concepts and techniques for image processing, in association with computer vision. Provides major understand of mathematical and statistical approaches. Demonstrate computer vision and image processing system design and implementation in advanced applications and prepare for research in computer vision and image processing. Topics include: Image formation and perception, image representation, sparse image analysis; Image segmentation, geometric transforms and registration; Morphological image processing; Object recognition, template matching, classification; Object detection and tracking: background modeling, kernel-based tracking; Camera models, stereo vision.

Analysis and Design (Synthesis) of Telecom Modules (A; cross-listed)

Big Data Processing and Analysis (A,B)
Effective compression techniques for high-volume data sets: sampling, histograms, wavelets; Approximate query processing; Continuous data streams: basic models, problems, and applications; Algorithms and tools for data-stream processing: reservoir sampling, basic sketch structures (AMS, FM, etc.); Distributed data streaming: Models and techniques; Modern big data management systems.

CAD Tool Development for Integrated Circuit Design (B, C; cross-listed)
The purpose of this course is to understand what CAD tools are, including tradeoffs of how utilities such as sed/awk or perl vs. the use of Python lead to the development of efficient CAD tools. The range of CAD tools considered is in the full-stack design flow (but mostly the back-end). The methodologies and mathematics which are used to develop CAD tools, as well as problems which arise in the process are considered. Such problems may be the rate of convergence, the choice of the correct mathematical tools (e.g. Monte Carlo methods vs. graph-based methods for place and route), or the tradeoffs of CAD tool quality vs. computational requirements (e.g. why can’t we use Spice for circuits with one billion transistors?). The course is breadth-oriented and as such it covers the entire range of CAD-tool development: circuit simulation (with analytical methods such as Newton-Raphson, simplified switch-level models, and macromodels), netlist extraction (and manipulation) from layout, placement, routing, power analysis, formal verification/model checking, testing/testability. The course does not cover at all graphical interfaces – only “command line” tools are considered,
as the focus of the course is on the tools themselves and not the user interface. The course has very extensive programming exercises (typically in C/C++) spanning the range of the material taught, plus a project to cover one aspect in more depth. The project may be a mini-SPICE simulator for up to 100 MOS transistors, or a Monte-Carlo-based place and route tool for standard cells.

**Coding Theory (A)**

**Computational Geometry (B; cross-listed)**

**Convex Optimization (A, B; cross-listed)**

**Data Management and Processing in Sensor Networks (B; cross-listed)**

**Decision Making and Learning in Multi-Agent Worlds (B)**

**Design of VLSI and ASIC Systems (C; cross-listed)**

**Detection & Estimation (A, B)**

Electronic Energy Management Systems (C; cross-listed)

Elements of Mathematical Analysis (A, B; cross-listed)
Metric Spaces, compactness, completeness, Baire’s Theorem, Lebesgue Integral, measurable Sets, Linear Operators on normed spaces, the three basic principles of Functional Analysis, Krein-Milman’s Theorem.

Information Management Methods (B)
Processing, archiving, and searching of information including documents, one-dimensional signals, still and moving images (video) in information systems and the Internet. Classic models of information retrieval (binary, relational, probabilistic), information clustering and clustering algorithms (partitional, hierarchical, hybrid algorithms), clustering applications grouping in document collections. Visualization of one-dimensional signals and images in multimedia systems. Feature extraction (color, texture, shape, and spatial relationships) from images. Retrieval methods for one-dimensional signals and images. Indexing techniques in information systems for documents and multimedia information (inverted files, k–d trees, grid files, R–trees, space filling curves). Design of information systems on the Internet, management and analysis of information on the Internet (PageRank and HITS methods). Web crawling and focused crawling. Introduction to Semantic Web. Ontology basics, ontology tools, and their application to information systems. Basic processing techniques and analysis of still and moving images (video) in information systems. Compression techniques, JPEG, MPEG–1, 2, 4, 7 standards. Video segmentation into shots, shot aggregates.

Introduction to Probabilistic Graphical Models (PGM) & Inference Algorithms (A, B)
PGMs encode (conditional) dependencies among random variables on carefully crafted graphs. Such description is powerful enough to describe a variety of many famous algorithms, such as (Gaussian) Belief Propagation, Kalman Filtering, Viterbi, Expectation-Maximization. This class offers an introduction in representation with PGMs, algorithms for exact inference, approximate inference, and learning/estimation: Directed acyclic graphs (DAGs) (Bayesian Nets) factorization theorem and semantics (I-map, d-separation, p-map). Undirected graphs (Markov Blanket, Hammersley-Clifford theorem), factor graphs (and techniques to convert), Gaussian Graphical Models. Exact Inference (elimination algorithm, sum-

**Introduction to Quantum Information (B, C; cross-listed)**

**Machine Learning (A, B)**

**Modeling and Performance Analysis of Communication Networks (A; cross-listed)**
Introduction to the Stochastic Modeling of Communication Networks. Quick Review of Basic Probability and Stochastic Processes Concepts: Random Variables, Expected Values and Conditional Expectations, the Bernoulli Stochastic Process and Sums of Independent Random Variables, the Poisson Stochastic Process and its Main Properties. Discrete Time Markov Chains (Properties, Classification of States, Limiting Behavior and Applications). Introduction to Modeling of Communication Networks via Queueing Theory: Little’s Theorem, Markovian Queues (M / M / 1, M / M/ m, M / M / m / m), the Queue with Generalized Distribution of Service Times (M / G / 1), the M / G / 1 Queue with Server Vacations, Markovian Queues with Customer Arrivals of Different Priorities, Reversible Markov Chains – Burke’s theorem, Open Queueing Networks – Jackson’s Theorem. Applications in the Design, Modeling and Performance

Nonlinear Systems (A)

Number Theory and Cryptography (A, B)

Optoelectronics (C; cross-listed)

Physics, Technology and Applications of Electronic Imaging Sensors and Systems (C)
Photodetectors, photodiodes and phototransistors, photovoltaic, band gap and spectral response, responsivity, quantum efficiency, noise types, time response, photodiode circuits, medical uses in spectroscopy, dosimetry etc., CCD silicon imaging sensors, charge storage and transfer, charge to voltage conversion read our circuits, noise, full well capacity and dynamic range, CMOS silicon imaging sensors, correlated sampling, color imaging with silicon detector, infrared photon and thermal cameras, X-ray cameras, performance evaluation-Modulation Transfer Function (MTF) of imaging systems, digital X-ray imaging systems: technology and quality assessment, applications in hyperspectral imaging and noninvasive medical diagnosis.

Principles of Distributed Systems (B)

**Probabilistic Robotics (B)**

**Quantum Technology (B, C; cross-listed)**
Randomized Algorithms (A, B; cross-listed)

Reconfigurable Computer Systems (B; cross-listed)
Introduction, definitions, Reconfigurable logic as a means of computations. Historical examples (Splash 2, RaPiD, Piperench) and areas of applications (DNA sequencing, discrete mathematics problems, image processing, speech processing, etc.). Comparison of FPGA systems with other implementation technologies (DSP, VLSI, conventional computers CPU, and Graphics Processing Units-GPU). Evolution of CAD tools for synthesis and place and route of reconfigurable designs, high-level synthesis (HLS) tools. Evolution of FPGA architectures. Granularity of subsystems and large hardcore subsystems (Embedded processors, BRAM, CAM, PLL/DLL, etc.). Dynamic reconfiguration and partial reconfiguration—opportunities and limitations. Semester project.

Secure Systems (A, B)
The goal of the course is the introduction of students into state-of-the-art research topics in the area of network and systems security. Topics include: access control models and mechanisms, malware, phishing, botnets, spam, denial of service (DoS), code injection, race conditions, and defenses.

Selected Topics in CMOS Analog Circuit Design (C)
Introduction to the design of advanced analog integrated circuits (ICs). Introduction to nanometric CMOS technology. Evolution of CMOS technology and scaling according to Moore's law. Conventional bulk CMOS, SOI CMOS, FinFET and other multi-gate CMOS technologies. High-voltage and power MOSFETs. Advanced MOSFET compact models and process design kits (PDKs) for the design of integrated circuits. Characterization and modeling of MOSFETs from DC to high frequencies and noise. Principles of advanced analog/RF IC design. Design of high-frequency amplifiers and oscillators.

Selected Topics in Databases (B)
This course covers a selection of the following topics: Design and implementation issues in databases. Design and implementation of relational systems. Design and implementation of object-oriented systems. XML databases. Query optimization in databases. Optimizing the performance of applications with design at the physical level, cost optimization for transactions, recovery. Distributed databases. Data Warehousing. Data mining on databases. Continuous Databases. Stream Processing. Big Data Systems and Frameworks.
Selected Topics in Electric Measurements Systems (C)

Selected Topics in Electric Power Systems (C)
State of the Art and future prospects for Electric Power Systems. Technical challenges in generation, transmission and distribution of electric power, control and supervision systems. The main subjects examined in the course are the following: characteristics and technical challenges of distributed electric power generation, microgrids (island and grid-connected operation), smart demand response, smart grids and their applications (smart metering, distributed control techniques, load shifting), active distribution networks, energy management of large clusters of electric vehicles connected to the network, “smart” electric energy storage, virtual power plants, hybrid power plants, "smart" producers-consumers of electricity (prosumers), flexible electric power transmission systems, high voltage direct current interconnection systems.

Selected Topics in Mathematical Biology (A)

Selected Topics for User Interface Interaction Design (B)
The aim of this course is to analyze use cases for user interface design principles, including interaction design rules, implementation of user interfaces, quantitative and qualitative evaluation metrics for user interface design. Selected use cases of psychophysical methodologies are going to be presented in relation to perceptual thresholds of user sensitivity regarding issues which negatively affect user interaction with technological systems.
Selected Topics in Computer Graphics (B)

Stochastic Processes and Time Series Analysis (A, B, C; cross-listed)
The concept of stochastic process (continuous-discrete time), Simple stochastic processes (sequences of independent random variables), Expectation, autocorrelation and autocovariance functions, Non-negative definite functions, Impulse function (Dirac delta), White noise process, Stationarity in the strict and wide (weak) sense, Permissible autocovariance models, Frequency domain description, power spectral density, periodogram estimation, Gaussian stochastic processes, Wiener stochastic process, Fractional Brownian motion, Convergence in the mean square sense, Continuity and differentiability for stochastic processes, Poisson process, Basic concepts of time series, The trend-fluctuations-noise model, Bias and consistency of statistical estimators, Non-linear transformations for heteroscedastic time series, Estimation and elimination of trend and periodicity, Discrete-time models of stochastic processes: moving average (MA), autoregressive (AR), and autoregressive moving average (ARMA), Yule-Walker equations, Estimation of model parameters and linear prediction (basic principles).

Theory of Probability and Random Processes (A, B)

Topics in Advanced Automatic Control (A)
Optimization theory of static nonlinear functions of many variables with or without constraints. Introduction to calculus of variations for the minimization of functionals under various boundary conditions. Functional minimization theory for multivariate

Visualization and Virtual Reality (B)
The aim of this course is the familiarization with visualization and virtual reality technologies as well as the development of virtual reality systems, employing industry-standard software tools for 3D modelling and APIs and software platforms for the implementation of 3D interactive applications. The course is evaluated based on the successful technological development of an interactive virtual reality and 3D interactive application, based on principles of human computer interaction.