NATIONAL TECHNICAL UNIVERSITY OF ATHENS

TEAM

TRANSLATIONAL ENGINEERING IN HEALTH & MEDICINE

MASTER OF SCIENCE

TRANSLATIONAL ENGINEERING IN HEALTH AND MEDICINE

STUDENT HANDBOOK **2023-2024**

MASTER

TEAM

CONTACT US

International M.Sc. Program "Translational Engineering in Health and Medicine"
School of Electrical and Computer Engineering, NTUA
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FACULTY

Learn from professors and researchers from top-ranked engineering Schools at a world-class technical university.

CURRICULUM

Academically rigorous coursework that links research-backed concepts to practice and accelerates impact in the healthcare domain.

ENTREPRENEURSHIP

Cultivate entrepreneurial skills to deliver high-impact solutions powered by deep science and technology.

GLOBAL NETWORK

Gain hands-on experience in the healthcare domain and build your professional network by interacting and connecting with a diverse community of experts from the industry, clinical sector, and regulatory bodies.

STRATEGIC COLLABORATIONS

Opportunities for internships and a richer academic experience are available to students through a strategic collaboration with Columbia University and the support of Bodossaki Foundation.

FAST FACTS

- ✓ 18 months duration
- ✓ Starts October 2023
- ✓ Located in NTUA Campus
- ✓ Courses in English
- ✓ 90 ECTS in total

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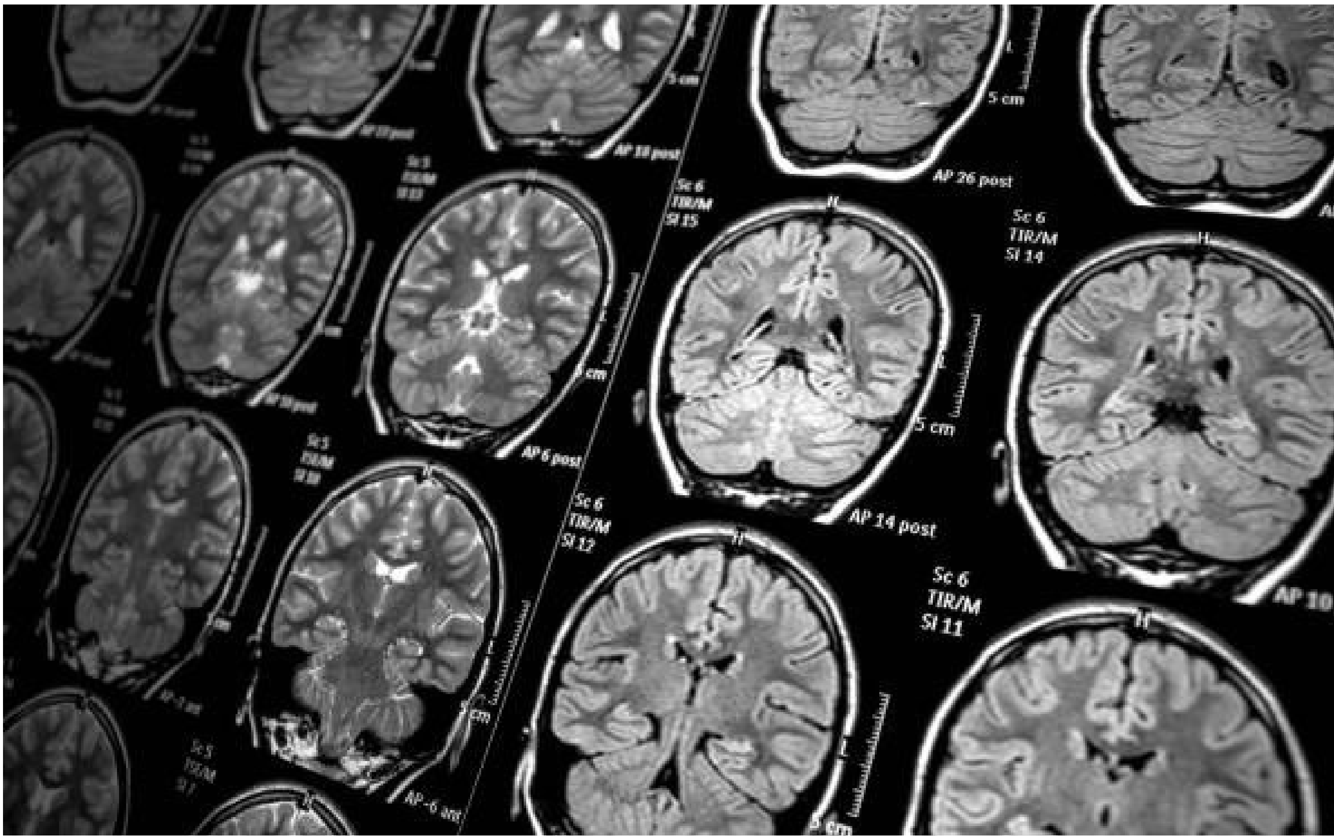

INTRODUCTION

Translational Engineering is the process of translating engineering research findings and discoveries into innovations and functional products. Applications of Translational Engineering in Health and Medicine focus on the development of devices and services to improve the public and individual health.

While funding for biomedical research has increased exponentially in recent years, there has been no corresponding increase in the development of practical solutions to clinical needs. Engineering and Life Sciences graduates need advanced and interdisciplinary training towards this direction. The international Master of Science (M.Sc.) in Translational Engineering in Health and Medicine, organized by the School of Electrical and Computer Engineering (ECE) in collaboration with the School of Mechanical Engineering (ME) of the National Technical University of Athens (NTUA), is designed to bridge that gap by preparing students to pioneer the transformation of innovative technologies into commercial devices and services with a significant socioeconomic impact in the field of health.

The program builds on NTUA's decades of foundational work in biomedical engineering and science and focuses on cultivating deep knowledge and catalyzing interdisciplinary efforts to address urgent healthcare challenges.

The interdisciplinarity of staff, students, and learning subjects are the key features of the M.Sc. in Translational Engineering in Health and Medicine at NTUA.

Students will work on cutting-edge topics in biomedical data science and artificial intelligence, neuroengineering, multi-scale modeling, digital health, intelligent reality, healthcare robotics, and biomedical microelectromechanical systems (BioMEMs) among others. The curriculum focuses on instilling entrepreneurial and leadership skills in students as well as exposing them to all of the steps involved in translating research discoveries into innovative medical products and services. Seminars highlight emerging research in bioengineering and provide training in research ethics. The program fosters a multidisciplinary and multisectoral approach through student internships in research labs, clinical departments, and industry.

PROGRAM OVERVIEW

PROGRAM STRUCTURE

This program is offered full-time and includes two semesters of coursework and one semester of Master thesis research. The maximum study period is two years. To earn the M.Sc. degree, students must: (i) attend and successfully pass 7 compulsory and 5 elective courses, corresponding to a total of 60 credits (30 per semester) and (ii) complete and successfully defend their M.Sc. thesis (30 credits). The enrollment in the third semester of studies and the assignment of the Master Thesis can take place at the end of the first year of studies, provided that the student has successfully completed at least half of the M.Sc. program courses by that time. The M.Sc. thesis is written in English.

FACULTY & COLLABORATORS

The M.Sc. program is taught by faculty from NTUA and collaborating Universities and research centers. Distinguished guest speakers from industry, the clinical sector, and regulatory authorities are also invited to deliver lectures and interact with students.

PROGRAM GOALS

The goal of the M.Sc. in Translational Engineering in Health and Medicine is to provide students with:

- the scientific, technological, regulatory, and business skills necessary to translate scientific discoveries into public and individual health benefits
- advanced research abilities so that they can conduct independent research and contribute to the creation of new knowledge in the field of Translational Engineering in Health and Medicine
- professional skills that will enable them to serve as healthcare executives with specialized knowledge in the scientific areas of this program and meet the growing needs of private and public enterprises, agencies, and services in Greece and abroad.

REGULATION

Studies Committee (SC)

CURRICULUM

- The International Postgraduate Studies Program awards a Master’s (M.Sc.) degree in the area of Translational Engineering in Health and Medicine after successful completion of the relevant course of study.
- This program is offered full-time and includes two (2) semesters of coursework and one (1) semester of M.Sc. thesis research.
- To earn the M.Sc. degree, students must: (i) attend and successfully pass 7 compulsory and 5 elective courses, corresponding to a total of 60 credits (30 per semester) and (ii) complete and successfully defend their M.Sc. thesis (30 credits).
- The courses (both compulsory and electives) offered each academic year are determined by competent bodies' decisions and are listed in the student handbook and on the Master's website.
- The courses of the program are taught in English, and the M.Sc. thesis is written in English as well.

COURSE ATTENDANCE & STUDENT EVALUATION

- Attendance of the courses and participation in the related educational activities is compulsory. The Special Interdepartmental Committee (SIC) may excuse certain absences in the case of particularly serious and documented reasons for the graduate student's inability to attend, with a maximum number of absences not exceeding 1/3 of the lectures. A postgraduate student who has not completed the required number of attendance hours in a course has the right to repeat the course (or other equivalent course assigned by the SIC) in the next and final academic year of study.
- The courses are graded on a scale of 0 to 10, without fractions, with a minimum pass grade of 5. According to each course's requirements, the course grade is derived not only from the final examination, but also from student performance in assignments, laboratories, study groups, group projects with personal presentations, and other activities. Only the M.Sc. thesis grade, which is calculated as the average of the marks given by the individual examiners, may include half a fractional point.

COURSE ATTENDANCE & STUDENT EVALUATION (cont'd)

- The final examination takes place after the completion of the teaching period, in accordance with the ECE NTUA Academic Calendar for Postgraduate Studies and the relevant SIC's decisions. The results are announced and issued after the final examination.

- Students are not allowed to retake exams. In rare circumstances, the SIC may allow an exceptional supplemental examination in no more than 1/4 of the courses every academic period, and only if the student was unable to be examined due to force majeure. In extraordinary circumstances, the SIC may organize an additional exam period.

- Students who fail a course may re-enroll the following academic year in the same (or a different) course (if it is an elective).

- If a postgraduate student fails the examination of a course or courses and is deemed not to have successfully completed the program under the provisions of this Regulation, he or she may be examined, at his or her request, by a three-member committee of faculty members, appointed by the SIC, who have the same or related subject to the course being examined. Lecturers of the course are excluded from the three-member committee.

- To complete the 13 teaching weeks, the lectures that were not conducted will have to be rescheduled. The SIC will decide and announce the time of rescheduled lectures, ensuring that the academic calendar is followed as closely as possible.

MASTER'S THESIS

- The Master's (M.Sc.) thesis can be assigned at the end of the second educational period of the first year of studies, provided that the student has successfully completed at least half of the M.Sc. program courses by then. The ~~steering committee~~ will decide whether or not students will be assigned their M.Sc. thesis from the beginning of the second academic year if they have not successfully completed all of the courses in the first two semesters.

- Students submit an application with the proposed thesis title and supervisor, ~~along with an abstract of the proposed research~~. Based on the application, the SC appoints the thesis supervisor and establishes the three-member Examination Committee for the approval of the thesis. The Examination Committee consists of the supervisor, other faculty members, teaching staff or researchers of levels A, B, C, who hold a PhD. The members of the Examination Committee must have the same or a related scientific specialization as the M.Sc. program. On the supervisor's recommendation, the postgraduate student may be assisted in conducting his/her M.Sc. thesis by PhD students, postdoctoral researchers, as well as other NTUA scientific collaborators or invited professors. Where necessary, technical staff may be involved to provide laboratory support to postgraduate students. The M.Sc. thesis grade is calculated as the average of the three examiners' grades on a scale of 1-10, rounded to half a fractional unit, with a minimum passing grade of 5.5/10. The SIC establishes uniform evaluation criteria.

MASTER'S THESIS (cont'd)

- The text of the M.Sc. thesis is composed according to a template approved by the SIC and includes a 1,200 to 2,000-word summary, a table of contents, bibliographical references, and a 300 to 500-word abstract. Following the approval of the M.Sc. thesis by the Examination Committee, the postgraduate students are required to submit (i) ~~a copy and an electronic file of their thesis at the NTUA Central Library and (~~ii) the electronic file of their thesis to the NTUA's Institutional Repository.

- If the M.Sc thesis is not completed successfully by the end of the third academic semester, it may be continued in the following academic semester.

- In all cases, a passing grade for the courses and the M.Sc. thesis is required for the M.Sc. degree to be awarded. If this is not achieved within the maximum study period, the postgraduate student will be issued a certificate of attendance for the courses in which he/she has received a passing grade and will be dismissed.

- The overall grade for the M.Sc. program is the weighted average of the grades in the courses and the M.Sc. thesis, which corresponds to one (1) semester of courses.

DURATION OF STUDY

- The regular duration of studies is three (3) academic semesters, and the maximum is two (2) years.

- In exceptional cases, where the student successfully completes his/her obligations for the award of the M.Sc. degree in a period shorter than the regular duration of the program, the SIC may, by decision, recommend to the NTUA Senate the award of the M.Sc. degree, provided that the student has completed at least one (1) year of studies in the program.

- Starting with the initial registration, the maximum period of studies in the M.Sc. program is two (2) years. At the end of the second year, the SIC decides to discontinue the course of study and issues a certificate listing the courses and corresponding grades that the student has successfully completed. In exceptional cases, the SIC may grant a short extension of up to one (1) year following a documented decision.

- By submitting a written request, postgraduate students may temporarily interrupt their studies for a duration of not more than two (2) semesters. Suspended semesters do not count toward the maximum period of regular study.

COURSES

Fall Semester	
Course	ECTS
Life Sciences for Engineering [1]	5
Engineering for Biomedicine [2]	5
Biostatistics and Machine Learning	5
Biosignal acquisition and processing	5
Research methodology	5
Translational bioinformatics	5
Biomechanics	5
Biodesign Fundamentals	5

(1) Compulsory course for engineers
(2) Compulsory course for health scientists
(3) Prerequisite: Biodesign Fundamentals

Spring Semester	
Course	ECTS
Medical imaging and image analysis	5
Computational modeling and simulation for medicine	5
Artificial Intelligence in healthcare	5
BioMEMS	5
Introduction to neuroscience and neural engineering	5
Healthcare robotics	5
Biodesign Innovation Process [3]	5

Compulsory Elective

Life Sciences for Engineering

An introductory outline of the basic anatomy and physiology of the human body for engineers. The objective of this course is to present the various levels of structural organization of the body, from chemical through cellular and tissue organization to organ, system, and whole body structure and function. The role of physical principles and phenomena as they are known to exist and apply to living systems will be highlighted in engineering terms. The aim is to (i) develop a quantitative intuition of biological systems; (ii) understand how principles in engineering can be used to study biological processes; and (iii) understand the relationships between structure and function at different size and time scales. Guest lectures will include engineers and medical scientists to discuss the relationship between recent advances in biomedical engineering and the underlying anatomy and physiology.

Engineering for Biomedicine

The course provides an overview of the fundamental concepts and principles of engineering as it applies to medicine and healthcare. Basic principles of mathematics, computational thinking, physics, mechanics, and electronics will be covered, along with medical use cases, so as to achieve an understanding of advanced technological achievements in healthcare and medicine. A problem-based introduction to building algorithms and data structures to solve problems in medicine and healthcare with a computer will also be provided. The course will include an introduction to (i) Matlab, as a standard tool to the fundamentals of computer programming and (ii) Python, via Google's Colaboratory (Colab) and DataCamp, focusing on the analysis and visualization of biomedical data. The course will empower those with non-engineering backgrounds with the knowledge required to critically evaluate and use these technologies in healthcare and medicine.

Biostatistics and Machine Learning

This course provides an introduction to statistical methods used in biological and medical research. Elementary probability theory, basic concepts of statistical inference, regression and correlation methods, and sample size estimation are covered, with emphasis on applications to medical problems. New statistical techniques for both predictive and descriptive learning as applied to the rapidly growing volume and complexity of data collected in imaging, genomic, health registries, and wearables are also covered. Machine learning algorithms for classification and prediction, particularly useful for big and complex data, will be presented. Topics include principles of supervised learning, including Bayesian classifiers, decision trees, regression models, support vector machines (SVMs), as well as principles of unsupervised learning, including clustering and density estimation.

Biosignal Acquisition and Processing

In this course, students learn about different physiological signals of electrical type such as Electrocardiography (ECG), Electroencephalography (EEG), Electromyography (EMG), and of non-electrical type such as blood pressure, blood flow-rate, cardiac output, cardiac rate, heart sound, respiratory rate, blood PH, plethysmography, blood gas analysis, etc. Students learn the origins of the biosignals, how they are collected and measured, what kind of sensor technology is required, and how they are analyzed. Signal processing techniques for different types of biosignals are discussed, including preprocessing for the removal of artifacts, coding, feature extraction, and modeling. The course includes hands-on sessions aiming to program these techniques in Matlab/Python, apply them to biomedical signals, and critically evaluate their performance.

Research Methodology

This course provides an opportunity for students to establish or advance their understanding of research through critical exploration of research language, ethics, and approaches. The course focuses on translational research and provides the fundamentals towards the design and conduct of "use-inspired" research, by building upon basic scientific research and synthesizing knowledge to develop a new or improved drug, device, diagnostic, or behavioral intervention. The course introduces the language of research, ethical principles and challenges, and the elements of the research process within quantitative, qualitative, and mixed methods approaches. Topics to be covered include: Searching and critically analyzing the latest research, Understanding statistics in quantitative research, Critical appraisal, Writing a research protocol, The setting up of a project, Patient and public involvement in research, Selecting robust outcome measures, Qualitative research methods, Assessing the impact of research, Getting research funding, Disseminating research.

Translational Bioinformatics

The course aims at presenting both algorithms and technologies for the analysis of biomedical data at the cellular and subcellular level (e.g. genomics and proteomics) and their translation into diagnostic, prognostic, and therapeutic applications in medicine. The course presents: a) the principles of molecular biology related to cell characteristics, DNA, RNA and gene analysis, focusing on the relation of biology with computer science, b) the basic techniques and algorithms for sequence comparison and statistical data processing, c) the basic IT infrastructure in which biological data is stored, with particular emphasis on online accessible databases along with the most important software tools used for their analysis (processing, cross-referencing, sharing and archiving of bioinformatics data, etc.), d) utility and limitations of public biomedical resources, e) issues and opportunities in drug discovery, and mobile/digital health solutions.

Biomechanics

This course introduces students to the mechanical principles that can be applied to study the structure-function relationship at different scales, from the molecular and cellular to the tissue and system scales. At the molecular and cellular levels, the course examines how mechanical quantities and processes such as force, motion and deformation influence molecular and cell behavior and function, with an emphasis on the connection between mechanics and biochemistry. At the tissue and system levels, solid and fluid mechanics are introduced, and applications in the musculoskeletal, respiratory, cardiovascular and urinary systems are discussed.

Biodesign Fundamentals

This is the first part of a two-semester course. Multidisciplinary teams of students identify real-world medical needs, evaluate their potential health and commercial impact, invent new health technology products to address those needs, and plan their full implementation into patient care. In this first course, the students either bring their own ideas or identify real-world needs by visiting clinical settings and interviewing end-users. Via a well-structured process that includes stakeholder analysis and market analysis, the students prioritize the ideas and select the ones that will be implemented in the subsequent semester in the course "Biodesign Innovation Process".

Medical Imaging and Image Analysis

The course is aimed to teach the principles of biomedical imaging and the foundation techniques required to process, analyze, and use medical images for scientific discovery and applications The first part of the course will provide students with the underlying principles of biomedical imaging including the basic physics and mathematics associated with each modality (X-ray CT, SPECT, PET, ultrasound, and MRI). The second part of the course will introduce concepts of digital images and will focus on analytic, storage, retrieval, and interpretive methods to optimally use the increasingly voluminous imaging data and integrate and understand them in the context of complementary molecular and clinical information to improve diagnosis and therapy in medicine. The use of Machine Learning to improve performance of sensing and imaging algorithms will be covered along with principles and algorithms of deep learning to process and analyze biomedical images. Topics covered in the course include: Types of imaging methods and how they are used in medicine; Image processing, enhancement, and visualization; Computer-assisted detection, diagnosis, and decision support; Access and utility of publicly available image data sources; Linking imaging data to clinical data and phenotypes.

Computational Modeling and Simulation for Medicine

Primary focus is on quantitative and computational methods to understand and/or model the pathophysiology of complex biological systems and develop efficient therapeutic interventions. Methods for multiscale/multilevel modeling and system identification are covered as applied towards understanding and analyzing biology, from individual molecules in cells to entire organs, organisms, and populations. Some examples include modeling of the glucose-insulin metabolic system, multi-scale cancer modeling and in silico oncology, construction of models to study cardiovascular system health.

Modeling and simulation of medical devices such as artificial kidney, artificial heart and heart valves, are also covered, along with prototype manufacturing using 3D printing technology.

Introduction to Neuroscience and Neural Engineering

This course examines a range of neural engineering approaches to investigating and intervening in the nervous system, emphasizing quantitative understanding and fundamental engineering concepts. Modern neural engineering techniques to measure and modulate neural activity and manipulate how an organism perceives, thinks, and acts are covered. The course focuses on the computing essence of neural processes and explores the relationship with molecules, spikes and synapses. Topics related to synaptic plasticity, learning and memory are examined. Based on the biophysics of brain computation, neurons are also explored as spike processing machines for creating intelligent algorithms inspired by the brain's complexity and self-organization.

BioMicroElectroMechanical Systems (BioMEMS)

This course targets to: (1) introduce fundamental design and microfabrication concepts of BioMEMS (including microfluidics and lab-on-chip systems) and (2) expose students to the relevant biomedical and biological applications of BioMEMS. The course is divided into three main sections: (i) Microfabrication and Materials of BioMEMS, (ii) Design of BioMEMS sensors and actuators, and (iii) BioMEMS applications.

Artificial Intelligence in Healthcare

This course involves a deep dive into recent advances in AI in healthcare, focusing in particular on deep learning approaches for medicine and healthcare problems. The course will start from foundations of neural networks and will then cover cutting-edge deep learning models in the context of a variety of healthcare data including image, text, multimodal and time-series data. Metrics unique to healthcare, as well as best practices for designing, building, and evaluating AI-based approaches in healthcare will be presented. Advanced topics on open challenges of integrating AI in healthcare, including interpretability, robustness, privacy and fairness will also be covered. The course aims to provide students from diverse backgrounds with both conceptual understanding and practical grounding of cutting-edge research on AI in healthcare.

Healthcare Robotics

The course intends to explore human robot interaction (HRI) in healthcare and cover the entire continuum of care from hospital to home, by tackling robotic challenges in surgery, assistance, and rehabilitation — three domains where robots are having the biggest impact. The course will also explore how artificial intelligence is used in surgical procedures, to improve precision diagnostics, in exoskeleton technology, and for patient care. Topics to be covered include: medical imaging-guided surgery; minimally-invasive surgery through miniaturization, novel actuation and sensing; robotic surgery at tissue and cell levels; autonomous robotic systems to assist with daily living activities; multi-modal robot interfaces; robotics-based rehabilitation technologies; upper limb rehabilitation robots; wearable exoskeletons and sensors; implanted neural interfaces.

Biodesign Innovation Process (prerequisite: Biodesign Fundamentals)

In this course, students are introduced to various aspects of medical device entrepreneurship. The students acquire a very diverse set of soft skills and are exposed to all steps required to bring a research discovery to a medical product or service. Lectures will be centered around case studies and often given by guest speakers from start-ups, regulatory experts, patent attorneys, clinical trial specialists, and investment firms to give students a sense of the process and challenges in developing their own business idea. Students will have the opportunity to discuss case studies based on other people's experience of bringing medical devices to market and the specific challenges associated with the development of new products in the medical sector.

ADMINISTRATIVE FRAMEWORK

The M.Sc. program "Translational Engineering in Health and Medicine" is coordinated by the School of Electrical and Computer Engineering of the National Technical University of Athens (NTUA) and operates in collaboration with the School of Mechanical Engineering of NTUA. The administrative support of the program is provided by the School of Electrical and Computer Engineering.

Panayiotis Tsanakas

Dean of ECE NTUA

- ~~Nectarios Koziris~~, Professor, School of Electrical and Computer Engineering, NTUA

Special Interdepartmental Committee

- Konstantina Nikita, Professor, School of Electrical and Computer Engineering, NTUA
- George Matsopoulos, Professor, School of Electrical and Computer Engineering, NTUA
- Giorgos Stamou, Professor, School of Electrical and Computer Engineering, NTUA
- Leonidas Alexopoulos, ~~Associate~~ Professor, School of Mechanical Engineering, NTUA
- Christos Manopoulos, Professor, School of Mechanical Engineering, NTUA

Studies Committee

Chair of the Special Interdepartmental Committee

- Konstantina Nikita, MD, PhD, Professor, School of Electrical and Computer Engineering, NTUA

~~Steering Committee~~

- Konstantina Nikita, Professor, School of Electrical and Computer Engineering, NTUA
- George Matsopoulos, Professor, School of Electrical and Computer Engineering, NTUA
- Giorgos Stamou, Professor, School of Electrical and Computer Engineering, NTUA
- Leonidas Alexopoulos, Associate Professor, School of Mechanical Engineering, NTUA
- Christos Manopoulos, Professor, School of Mechanical Engineering, NTUA

Director of the Master Program

- Konstantina Nikita, MD, PhD, Professor, School of Electrical and Computer Engineering, NTUA

~~Deputy Director of the Master Program~~

- ~~Leonidas Alexopoulos, Associate Professor, School of Mechanical Engineering, NTUA~~

Secretariat of the Master Program

- Aimilia Kougkoulou, Administrative Staff, School of Electrical and Computer Engineering, NTUA

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- Effrosyni Kanta, Administrative Staff, School of Electrical and Computer Engineering, NTUA

Version: May 2023