NATIONAL TECHNICAL UNIVERSITY OF ATHENS

STUDY GUIDE

MSc PROGRAM
“AUTOMATION SYSTEMS”

2024 - 2025

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1 Information about the University

1.1 Name and Adress

National Technical University of Athens

Interdepartmental Postgraduate Programme "Automation Systems"

Heroon Polytechneiou 9

Zografou Campus

157 80 Athens, Greece

1.2 Academic Year/Semester Dates

All Postgraduate Programmes (MSc Programs) exclusively managed by NTUA fall under the "Unified Academic Timetable for Postgraduate Studies of the University". This timetable is proposed by the Postgraduate Studies Committee to the Senate by the end of July each calendar year and is approved by the end of July. The general principles for the structure and composition of the Academic Timetable of the MSc Program are as follows:

1.2.1 Duration and activities of the academic semesters

- **1st (Winter) Academic Semester, October - February:** At least 13 teaching weeks, a two-week Christmas break, and a two-week period for special educational needs and exams.
- **2nd (Spring) Academic Semester, February - June:** At least 13 teaching weeks, a two-week Easter break, and a two-week period for special educational needs and examinations.
- **3rd Academic Semester:** Undertaking, elaboration, and presentation of the Postgraduate Diploma Thesis (PDT), under the conditions outlined in paragraph f (see below).

Any missed classes must be rescheduled to ensure a total of 13 teaching weeks for all courses. Rescheduling is decided and announced by the Programme Studies Committee (PSC) of the Interdepartmental Postgraduate Programme (MSc Program), in accordance with the academic timetable.

a) All academic semesters have ten days to complete their examination requirements. For example, examinations for the first academic semester may be conducted in the first ten days of February or October respectively.

b) Registration of successful candidates as Doctoral Candidates or Postgraduate Students in the MSc Program for semester courses or prerequisite courses takes place during the first two weeks of October.

c) Applications for changing the Specialization of study will be considered by the Steering Committee (SC) if the applicant's degree grade is equal to or higher than the last admitted student's grade in the desired Specialization and if there are available positions. Applications must be submitted after the commencement of registrations and no later than two weeks after the start of classes.

d) Changing one elective course is possible until the end of the second week of classes. Withdrawal from a course will be evaluated by the SC upon request, which must be submitted no later than the fourth week of classes. It is noted that weeks of non-attendance of a course are considered absences.

e) The Secretariat issues a list of enrolled students for each course and sends it to the respective lecturers and the PSC of the MSc Program within the third week from the start of classes for each academic semester.

f) Each postgraduate student has the right to undertake a topic for their Postgraduate Diploma Thesis (PDT) after: (i) the beginning of their second academic semester of studies, (ii) successfully completing six out of the twelve required courses for graduation, (iii) at least four months before the PDT presentation, and (iv) successfully completing any designated undergraduate prerequisite courses by the PSC before undertaking the PDT. The completion of the PDT must not exceed the maximum duration of studies in the MSc Program, which is two years from the date of the first enrollment.

g) The “Unified Academic Timetable for Postgraduate Studies of the University” is as follows:

Time Period	**Activities**
First Academic Semester (October – Febryary) - 13 weeks	
First fortnight of October	Start - end of enrollment
Second Week of October	Start of classes. Two-week deadline for changing elective courses
Third week from the	Issuance of lists of enrolled postgraduate students in each course

start of classes	and separately of the prerequisite courses by the Postgraduate Studies Offices of the Administrative Services of the Schools*
By the 4th week of classes	Deadline for withdrawal from elective courses
End of 13th week	End of Classes
Special educational needs and make-up Week	Start of the period for special educational needs
Special educational needs and make-up Week	End of the period for special educational needs
Examination period	Start of a two-week examination period
Exam period	End of a two-week examination period
One week after the end of the exams	Submission of grades
Second Academic Semester (February-June) – 13 weeks	
First Monday after the end of the examination period	Start of enrollments and classes
Five days after the start	End of enrollments
Third week from the start of classes	Issuance of lists of enrolled postgraduate students for each course and prerequisite courses by the Postgraduate Studies Offices of the Administrative Services of the Schools*
By the 4th week of classes	Deadline for withdrawal from elective courses
End of the 13th week	End of Classes
Special educational needs and make-up Week	Start of the period for special educational needs
Special educational needs and make-up Week	End of the period for special educational needs
Examination period	Start of a two-week examination period
Examination period	End of a two-week examination period
One week after the end of the exams	Submission of grades
Last ten days of May	Announcements for the MSc Program for the next academic year

* For MSc Programs, the responsible school is the Coordinating one (School of Mechanical Engineering)

*Third Semester (June – September)***	
1st week of June	Undertaking of Postgraduate Diploma Thesis (PDT)
2nd week of September	Submission of PDT
3rd week of September	Presentation Week for PDT
4th week of September	Issuance of PDT results

1.3 Academic Authorities and Services

The Postgraduate Studies Office of the School of Mechanical Engineering covers the following actions:

i. Process for announcing calls for applications for admission.
ii. Providing information about the program during call for applications periods.
iii. Collecting documentation from candidates
iv. Enrollment of postgraduate students and updating their status at the beginning of each academic period.
v. Compiling a list of enrolled postgraduate students by program and course.
vi. Maintaining a record of course attendance.
vii. Keeping and updating a file for each enrolled postgraduate student throughout their studies.
viii. Issuing transcripts for postgraduate students.
ix. Preparing timetables and examination schedules.
x. Organizing educational visits.
xi. Maintaining a record of submitted exercises and postgraduate diploma theses.
xii. Continuously updating the program's website
xiii. Issuing all types of certificates and attestations upon request.
xiv. Managing scholarship award processes.
xv. Maintaining a computerized record of postgraduate students.
xvi. Supporting the PSC and SC of the MSc Program.
xvii. Providing all kinds of information and data related to the postgraduate studies of the School and making them available on the internet.
xviii. Managing the processes for awarding Diplomas of Postgraduate Studies (DPS).

** For the MSc Program "Automation Systems" the provisions outlined in paragraph f apply

xix. Updating the record of DPS holders.

1.4 National Technical University of Athens

Founded in its initial form as the “School of Arts” in 1836, almost simultaneously with the establishment of the modern Greek state. By royal decree “On education in architecture”, the Technical School was established, initially operating only on Sundays and holidays, offering classes to those who wished to be educated as architects.

The influx of prospective students was so great, despite the remote location, that in the spring of 1840, a school of continuous (daily) operation was added alongside the Sunday school, while classes multiplied and expanded. At that time, the “Polytechnic School” was established in its own building on Piraeus Street. With the zeal of the students and the teachers, the school continuously developed, and its standards rose.

Soon, the School was upgraded to meet the broader needs of domestic reconstruction and industry. The duration of studies was extended, the curriculum enriched with new courses, and the administration fell under the "Commission for the Promotion of National Industry." However, the limited capacity of the Vlahoutsi residence on Piraeus Street (where the Athens Conservatory was later housed) did not allow the ambitious goals of the School to be met. Thus, in 1871, the School began relocating to new buildings on Patission Street. Buildings that were first envisioned by Nikolaos Stournaris (“with the rest of my fortune”, he wrote in his will in 1852, “let a splendid Polytechnic be built in Athens...”), leading his relatives and fellow citizens from Metsovo, Michael Tositsas, Eleni Tositsa, and George Averoff, to embrace his idea and follow his example.

In 1887, with the establishment of four-year schools of “Civil Engineering” and “Machinist Engineering” (later “Mechanical Engineering”), the Polytechnic School or National Technical University of Athens (NTUA), as it became more widely known, “educates men of superior technical training for public service, industry, and construction”, comparable "to those graduating from the great technical schools of Europe”. By law in 1914, the university is established as the “National Technical University of Athens”.

The last radical reform in the organization and administration of the University took place in 1917 with a special law. NTUA acquired five Higher Schools: Civil Engineering, Mechanical - Electrical Engineering, Architectural Engineering, Chemical Engineering and Topographic Engineering. The transition from 1917 to today's organization of studies is the result of successive adaptations to the changing needs of the Greek economy in combination with the evolving extent and depth of the various fields of knowledge.

The youth uprising in November of 1973 and the shocking events that unfolded in the courtyards and classrooms of the Polytechnic School were the culminating moment of the student movement, a mature and massive political confrontation with the dictatorship and its supporters. Beyond its historical dimension and role in consolidating Democracy, the

Polytechnic School uprising inspired and mobilized the entire society in the pursuit of common demands and brought a new ethos to the social and political life of the country.

Today, the Polytechnic School, honoring its history and tradition, continues to live and pioneer in the social struggles for substantive Education, for the students' right to the future, and for Democracy.

The National Technical University of Athens (NTUA) was structured according to the model of the “Continental” European engineering education system, with a solid theoretical background and a standard duration of five years. Its significant national contribution and its internationally distinguished position are attributed to its high structural specifications, the high quality of its faculty and students, and the satisfactory level of its infrastructure. NTUA graduates were the central scientific lever of self-sustained pre-war development and post-war reconstruction, staffing both public and private technical services and companies with engineers who, by general consensus, had nothing to envy from their European colleagues. They also occupied important positions as teachers and researchers in both the Greek and international academic community.

Today, NTUA operates as a Higher Educational Institution (HEI) under state supervision as a legal entity of public law (LEPL) serving exclusively the public interest and is fully self-governing. The supreme elective governing body is the Senate, chaired by the Rector, and with the participation of Vice-Rectors, Departments Heads, representatives of the Faculty Staff and students from each School, as well as representatives of other bodies of the University.

Within the framework of Article 16 of the current Constitution, Article 1 of Law 1268/82, and the tradition, structure, and human and infrastructure of NTUA, the university, through the inseparable unity of studies and research, has as its primary institutional component of its mission, the provision of free public higher education of distinguished quality and the advancement of sciences and technology.

With a general mobilization of all its human resources, NTUA is undergoing a new qualitative upgrade: The overall reorganization of studies and research is a priority, with a modern vision, enrichment with new scientific and technical-economic orientations, and a radical improvement and enhancement of infrastructure and environmental spaces. At the same time, the obvious need for every serious University to operate and provide educational and research work through a well-organized and absolutely clear system of principles, objectives, procedures, duties, and rights led during the period 1998-2000 to the composition, approval, and institutionalization of a pioneering Internal Operating Regulation (Government Gazette 1098/B/05.09.2000) for the Greek and wider European Higher Education Area. The dominant strategic choice of NTUA in the new millennium, as explicitly expressed by its Internal Operating Regulation, is not only to maintain its position as a distinguished and internationally recognized public University of sciences and technology but also to continuously enhance this position, both in terms of its mission and all its fundamental operations. All other strategies, objectives and actions must be compatible with this overarching strategic choice.

With its emblem featuring Prometheus the Firebearer, its measure being humanity, and its main parameters being the quality of life and the protection of democratic rights and achievements, NTUA fulfills its mission through the realization of the invaluable social role of the historical “Universitas”. Consequently, it fosters the broader personal and social virtues of its teachers-researchers and students by:

- Cultivating skills for independent access to knowledge, synthesis, research, communication, collaboration, and project management.
- Highlighting integrated personalities that not only possess renewable scientific and technological knowledge but also know how to “stand” as scientists and “exist” as conscientious-responsible citizens.
- Offering an unwavering and effective contribution to meeting the scientific-technological, social, cultural, and other broader developmental needs of the country as a priority, as well as those of the international community.

1.5 Presentation of Schools that provide Postgraduate Studies

1.5.1 School of Mechanical Engineering (Coordinating School)

The National Technical University of Athens made its first appearance in 1837 under the name “Polytechnic School”, initially as a primary technical education university. It operated only on Sundays and holidays.

In 1840, a continuously operating school was added, and the courses were expanded and extended. The Polytechnic School was housed in its own building on Piraeus Street. With the enthusiasm of the students and teachers, the school continuously developed and raised its standards. The curriculum now included Mathematics, Chemistry, Drawing, Engineering, and Descriptive Geometry, with an educational organization comprising winter and summer semesters.

During the period from 1844 to 1862, in addition to the Sunday and daily school, a Higher School was established, which included Architecture and Fine Arts. During this period, Mechanical Engineering was also introduced as a subject.

In January 1856, lectures on “Magnetism” and “Static Electricity” were delivered for the first time, and in June 1860, the first telegraph operators were trained. From 1862 to 1864,, the

Polytechnic School underwent reorganization, introducing more technical courses. This trend continued through 1864 to 1873. A machine shop, known as the “Ironworks Factory” was established, and a “Telegraphic Factory” was created, while the telegraphic network expanded across the country. In 1873, the Polytechnic School moved to new buildings on Patission Street and renamed “Metsovion Polytechnic School”, in honor of the benefactors and donors from Metsovo. This structure remained unchanged after 1873. In 1881, a single-seat Telegraphic School was established, with a duration of studies of one year.

In 1887, the Metsovian Polytechnic School was divided, and the technical specialties were placed under the School of Industrial Arts, as it was named. Three four-year Schools were established: Civil Engineering, Mechanical Engineering, and Geodetic Surveyors. A detailed curriculum and internal regulations were developed. The operation of the Schools continued until 1914 when the University was renamed the “National Metsovion Polytechnic School” (or National Technical University of Athens) and placed under the jurisdiction of the Ministry of Public Works. Alongside the Schools of “Civil Engineering” and “Mechanic and Mechanical Engineering” (as the School of Mechanical Engineers was renamed), the legislative decree of 1914 provided for the establishment of Schools of “Architecture” and “Electrical and Telegraphic Engineering”. These Schools were designated as higher education institutions with four-year programs. Various lower-level educational activities were integrated into Schools for Foremen attached to the Higher Schools. A new organizational structure and academic regulations were established.

In 1917, another legislative decree converted the Higher School of Mechanical Engineering into the Higher School of Mechanical and Electrical Engineering and established additional schools for Architecture, Chemical Engineering, and Surveying Engineering. The Higher School of Mechanical and Electrical Engineering continually expanded its course offerings and developed new laboratories. All courses were mandatory.

By the 1960s, it became evident that the rapidly advancing technology necessitated the separation of the mechanical and electrical engineering disciplines. In 1963, the Production Engineering cycle was introduced within the Higher School of Mechanical Engineering, and in 1968, the Naval Architecture Department was established. Finally, in 1975, the Higher School of Mechanical and Electrical Engineering was split into two independent schools. The Higher School of Mechanical Engineering then included the Naval Architecture Department and the Production Engineering cycle.

In 1982, the implementation of the Framework Law for Higher Education Institutions resulted in the Department of Naval Architecture separating from the School of Mechanical Engineering. Consequently, the Higher School of Mechanical Engineering was renamed as the Department of Mechanical Engineering. Simultaneously, the personnel and educational, as well as research activities of the Department, were organized into six Sections: (Industrial Management and Operational Research, Heat Transfer, Mechanical Construction and Automatic Control, Nuclear Technology, Fluids, Processing Technology) which, of course, operated in close collaboration and mutual support.

In 1986, two additional cycles of study were established within the Department: Energy Mechanical Engineering and Construction Mechanical Engineering. In 1990, the program of Aeronautical Mechanical Engineering was also introduced. These four cycles of study allowed students to partially define their academic focus.

Students conduct laboratory work, while faculty members conduct research within the School's facilities. These activities support the School's three main priorities: educational activities encompassing lectures, exercises, labs, seminars, and dissertations; research activities including doctoral theses across the six Sections; and societal projects aimed at advancing technology in collaboration with industry, government, and private sectors.

1.5.2 School of Electrical and Computer Engineering (Participating School)

Since 1911, the “Electrical Laboratory” was established to oversee electrical and lighting installations, alongside practical training for students of the School. Over time, this laboratory expanded with additional instruments, focusing specifically on electrical engineering, becoming the cornerstone for subsequent electrical laboratories. These laboratories include: Electrotechnics, Electrical Machines, High Voltage and Electrical Measurements, Electric Power Systems, Wireless and Long-Distance Communication, and Electronics and Telecommunication Systems.

Courses offered by the School of Electrical and Mechanical Engineers were initially comprehensive and mandatory. However, the need to separate these two fields became evident in the 1960s due to rapid technological advancements, culminating in their formal division in 1975. To keep pace with technological progress, two new study cycles were introduced: Electronic Engineering and Energy Engineering.

With the implementation of the Framework Law for Higher Education Institutions in 1982, the School of Electrical Engineering was renamed as the Department of Electrical Engineering, organized into three Sections: Electrophysics, Electric Power, and Informatics. By 1984, the study cycles expanded to three, with the addition of Computer Engineering and Informatics.

In May 1991, the Department of Electrical Engineering was renamed as the "Department of Electrical and Computer Engineering" formally recognizing the field of Computer Engineering and Informatics.

Since 1993, a new curriculum has been gradually implemented, offering four specializations:

- Electronics and Systems
- Computer Science
- Communications
- Energy

Existing laboratories have been fully modernized, with the establishment of new ones, all interconnected through a network facilitating their full utilization

1.5.3 School of Chemical Engineering (Participating School)

The Higher School of Chemical Engineering in NTUA officially began its operation following the publication of Law 980 on October 24 and 30, 1917, and the issuance of the legislative decree on November 11, 1917. This commencement represented the culmination of numerous events that highlighted the School of Chemical Engineering to be autonomous. These events, which started shortly after the establishment of the Polytechnic School in 1837, mark the period before the School's founding.

The School started with a four-year curriculum, and began its operations in the following year, 1918-1919. The academic year 1917-1918 was used to set up the required laboratories.

In 1946, Law 1021 led to the division of the Higher School of Chemical Engineering into three departments, each with a five-year curriculum:

a) Department of Chemical Engineering

b) Department of Metallurgical Engineering

c) Department of Mining Engineering

During the 1950s and 1960s, the School underwent significant changes in teaching, coursework, and research activities. The gradual introduction of more advanced Mathematics and new subjects such as Reactor Design and Process Engineering modernized the School, aligning it with contemporary standards and establishing it more firmly as a School of Chemical Engineering.

Since 1960s, through continuous efforts, the School acquired a clear identity as a School of Chemical Engineering, aligning with recognized standards and the country's needs. However, the School's development was hindered during the dictatorship (1967-1974), but efforts to introduce modern concepts resumed immediately afterward.

By a presidential decree in October 1975, the Higher School of Chemical Engineering of NTUA, was divided into the following two Schools:

a) School of Chemical Engineering

b) School of Mining and Metallurgical Engineering

Significant changes in the operation of the School of Chemical Engineering occurred with Law 1268/82, which pertains to the general operation of Higher Educational Institutions. This law abolished the existing departments within the School and divided it into the following four Sections:

i. Chemical Sciences
ii. Analysis, Design, and Development of Processes and Systems
iii. Materials Science and Technology
iv. Synthesis and Development of Industrial Processes

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1.5.4 School of Mining and Metallurgical Engineers (Participating School)

The School of Mining and Metallurgical Engineering of the National Technical University of Athens (NTUA) was officially established by Law No. 1021/27.2.1946. This law divided the School of Chemical Engineering at NTUA into three separate Departments: (a) the Department of Chemical Engineering, (b) the Department of Mining Engineering, and (c) the Department of Metallurgical Engineering. The operation of the latter two Departments began in the academic year 1945-1946.

Prior to the establishment of the Departments of Mining and Metallurgical Engineering, several related courses were taught within other departments. Starting in 1878, the course "Mineralogy and Geology" was initially offered at the School of Civil Engineering, which was then known as the "School of Industrial Arts". Subsequently, the course "Iron Metallurgy" was introduced within the School of Mechanical Engineering. These courses continued to be taught until 1914, when the institution was renamed the National Technical University of Athens (NTUA). In 1917, the curriculum expanded with the addition of the course "Mining Works. In 1943, with Law No. 935, the Chairs of Special Mining, Iron Metallurgy, Special Metallurgy, and Prospecting & Applied Geology were established. However, it wasn't until the academic year 1945-1946 that the full-fledged five-year programs in Mining and Metallurgical Engineering were officially established and commenced.

In 1948, three years after the establishment of these Departments, they were merged into a unified Department titled "Department of Mining and Metallurgical Engineering", which remained under the auspices of the School of Chemical Engineers at the NTUA. Thus, from 1950 to 1952, graduates of NTUA received diplomas as either Mining Engineers or Metallurgical Engineers. Since 1953 and up to the present day, the diploma awarded has been unified, bearing the title "Mining and Metallurgical Engineer". During the academic year 1975-1976, the Department became independent from the School of Chemical Engineers and operated as the autonomous "School of Mining and Metallurgical Engineering". With the implementation of Law No. 1268/82 "Regarding the Structure and Operation of Higher Education Institutions" (Framework Law), the "Higher School of Mining and Metallurgical Engineering" was renamed back to the "Department of Mining and Metallurgical Engineers". The nine existing Chairs of the School were integrated into the following three Sections of the Department established by this Law:

- Section of Mining Engineering
- Section of Metallurgy & Materials Technology
- Section of Geological Sciences

In 1999, in an effort to enhance undergraduate studies, it was decided that the first seven semesters would constitute the core curriculum. Starting from the 8th semester, students could choose from five specializations, which are completed by the 9th semester:

a) Environmental Engineering and Geo-environment

b) Mining Technology

c) Geotechnology

d) Metallurgical Processes

e) Materials Science and Technology

From the academic year 2001-2002 onwards, the new system of specializations has been implemented. Furthermore, from the academic year 2002-2003, the Department of Mining and Metallurgical Engineering was renamed to the “School of Mining and Metallurgical Engineering”. Since 1993, the laboratories and all activities of the School have been relocated to new buildings in the Zografou Campus. It is presently known as the School of Mining and Metallurgical Engineering.

1.5.5 School of Naval Architecture and Naval Engineering (Participating School)

The School of Naval Architecture and Marine Engineering was established by Decree on May 15, 1969, and began its operation in the academic year 1969-1970. It originated from the Naval Mechanical Engineering program, previously a part of the School of Electrical and Mechanical Engineering at NTUA. The initiative to establish this school was led by the late Professor V. Frangoulis, who served as the Rector of NTUA during the academic year 1969-1970 and as Prorector in the preceding two years. With the Decree of May 15, 1969, the following three Chairs were established: Ship Theory, Ship Design and Construction, and Marine Engineering, which were filled by the Professors: Th. Loukakis, A. Antoniou, and I. Ioannidis, respectively. Each chair was supported by a Curator, two Assistants, and one Technician.

From the beginning, the School had its own number of admitted students, initially ten in its first year of operation, with the first Mechanical Engineering graduates completing their studies in 1974. In the academic year 1975-1976, the Higher School of Mechanical Engineering was divided into the Schools of Mechanical and Electrical Engineering, with the School of Naval Architecture and Marine Engineering being incorporated into the former. Finally, after the publication of Law 1268/82, by Decree of August 26, 1982, the School became independent.

Upon becoming an independent School, the faculty initially consisted of five members: three Professors and two Lecturers. Shortly after, the General Assembly of the School announced new positions, increasing the number of faculty members to twenty-two. This expansion significantly revitalized the School's educational program, introducing new courses and updating existing ones. The School also engages in vigorous and multifaceted research activities, with a notable milestone being the establishment of the Experimental Tank in 1979. Detailed descriptions of the School's research activities are provided in separate informational publications.

According to Ministerial Decision 131/483, published in the Government Gazette/Issue 899/Volume 2 - December 13, 1993, the School has already established and operates the following four Sections:

- Section of Ship Design and Maritime Transport Studies
- Section of Naval and Maritime Hydrodynamics
- Section of Marine Mechanical Engineering
- Section of Marine Constructions

1.5.6 School of Applied Mathematics and Physical Sciences (Participating School)

The School of Applied Mathematics and Physical Sciences (SAMPS), formerly General Department of the NTUA, was established in accordance with the provisions of Law 1268/82. Its mission is to provide education and conduct research in the general scientific background of engineering across all disciplines. It is the largest school at NTUA in terms of faculty members. The School possesses a high level of scientific expertise and infrastructure and comprises four Sections:

- Section of Mathematics
- Section of Physics
- Section of Engineering
- Section of Humanities and Social Sciences and Law.

2 Information about the MSc Program "Automation Systems"

2.1 General Description

The objectives of the Interdepartmental Postgraduate Programme "Automation Systems" are: (a) enhancing scientific and technological research in the fields of Manufacturing & Production Systems and Automated Control and Robotics Systems, and (b) generating new knowledge in these fields.

Specifically, the MSc Program aims to upgrade research and provide interdisciplinary and specialized knowledge, targeting both theoretical and practical laboratory training in the strategically significant area of Automation Systems for our country. This is achieved through the interdisciplinary and interdepartmental nature of the Program, which covers a broad spectrum of technological and scientific fields, such as:

- Support and design systems for construction and industrial production, such as CAD, CAE, CAM systems, etc.

- Automation and industrial production systems
- Theory and application of automatic control systems
- Robotic and mechatronic systems and their control
- Automation technology for thermal, physical, chemical, and mechanical processes
- Automated management and financial support systems for industrial production
- Occupational safety systems and facilities, maintenance, waste processing, etc.
- Automated management and financial support systems for industrial production, including production costing systems
- Automated systems for selected sectoral production, such as inert materials, chemical industry, etc.

2.1.1 Admission Requirements

The admission requirements and procedure are as follows:

A. The MSc Program "Automation Systems" accepts candidates following an open call. Eligible applicants include graduates of Engineering Schools from NTUA or other equivalent Greek Higher Education Institutions (HEIs), as well as equivalent Schools of HEIs abroad. Additionally, graduates from equivalent Schools in related fields, from scientific or technological disciplines, both in Greece and abroad, are accepted, provided that obtaining the Diploma of Postgraduate Studies (DPS) does not imply obtaining the basic diploma of NTUA. Final-year undergraduate students of NTUA or HEIs in the aforementioned categories are also considered, provided they submit proof that they will obtain their diploma/degree before the start of the MSc Program. Furthermore, holders of degrees from other Schools are accepted in accordance with applicable regulations.

B. The Program of Studies Committee (PSC) (Article 12 para. c Law 2083/92) decides, based on the School the candidate graduated from, any additional undergraduate courses the candidate must attend and pass before joining the MSc Program. If the required courses are up to four (4), they can be attended concurrently with the postgraduate courses. These courses may come from the Undergraduate Curriculums of the Schools participating in the MSc Program. These courses must be successfully passed within the prescribed duration of the MSc Program and definitely before undertaking the Postgraduate Diploma Thesis (DPS). The maximum duration for attending additional courses is two (2) academic semesters. The Steering Committee (SC) can exempt candidates from attending undergraduate and elective MSc

Program’s courses if they have successfully completed related courses in their undergraduate or other postgraduate studies.

C. The selection of postgraduate students is based on the criteria and requirements set by current legislation. The Programme Studies Committee (PSC) is responsible for determining the specific details of how these criteria are applied and weighted. Additionally, the PSC may establish supplementary criteria or require examinations in specific courses or interviews, the results of which will be considered during the selection process.

The following selection criteria are taken into account:

1) The overall grade of the diploma/degree
2) The rank of the diploma/degree grade in relation to the grades of other graduates in the same School/Department and academic year
3) The grades in undergraduate courses related to the Postgraduate Programme
4) The performance and subject of the undergraduate thesis, where applicable
5) Any other postgraduate degrees related to the MSc Program’s discipline
6) The candidate's research, professional, or technological activities
7) Foreign language skills, with a very good knowledge of English being required for the MSc Program “Automation Systems”
8) Computer literacy
9) Letters of recommendation
10) For employed candidates, the needs and prospects of their employer.

The Programme Studies Committee (PSC) determines the details for implementing the selection criteria for postgraduate students, as outlined in Article 7 of the Operational Regulation of the MSc Program. This includes setting the language proficiency levels, defining supplementary criteria, and conducting examinations or interviews, the results of which are considered during the selection process. If an interview is conducted, it is scheduled by the PSC and carried out by a three-member Selection Committee appointed by the PSC, comprising faculty members and lecturers in the MSc Program, with one member being from the PSC.

D. The list of successful candidates, following the recommendation of the Selection Committee, is approved by the PSC and the General Assembly of the Coordinating School is informed.

E. In addition to the number of admitted students, one scholar from the State Scholarships Foundation (IKY) who has succeeded in the relevant internal postgraduate competition in the field of the MSc Program, and one foreign scholar of the Greek State, may be accepted into the MSc Program. The number of scholars may be increased by a decision of the PSC.

F. Members of the Special Teaching Staff, Laboratory Teaching Staff, and Technical Laboratory Staff categories who meet the requirements may apply to enroll as supernumeraries, with a limit of one per year, in an MSc Program of the School where they are employed, provided their field of study is related to their professional duties.

The maximum number of admitted postgraduate students is determined by the number of lecturers in the MSc Program, the student-lecturer ratio, the material and technical infrastructure, and the availability of lecture rooms. For the MSc Program "Automation Systems" (which is conducted exclusively in English), the number of postgraduate students should be set so that at least half are Greek students, provided there is a sufficient number of applications. Accordingly, the total number of postgraduate students will be adjusted.

2.1.2 Educational and Professional Objectives

The fields covered by the MSc Program "Automation Systems" are inherently interdisciplinary and continuously evolving. Therefore, they require the collaboration of capable scientists and engineers who can innovatively address emerging technological challenges. With this in mind, the MSc Program "Automation Systems" aims to specialize participants in modern methods and techniques of interdisciplinary collaboration and research. This specialization enables them to adequately meet the increasing demands of both the public and private sectors in the country, as well as more broadly, in the scientific fields covered by the MSc Program. The program also aims to train scientists who are highly skilled, capable of generating new knowledge, and responding to contemporary societal needs and technological advancements.

In all cases, it is deemed necessary and is pursued to link the educational and research processes of the MSc Program with production, ultimately aiming to contribute to the technological development of the country.

2.1.3 Access to Further Studies

1. Holders of the Diploma of Postgraduate Studies (DPS) – Master of Science can apply to continue their postgraduate studies towards obtaining a Doctoral Degree (PhD) in one of the participating Schools of the MSc Program "Automation Systems", according to the

process described in the following paragraphs and in line with the decision of the NTUA Senate (Meeting 17/10/97).

2. In the case of a positive evaluation, the Coordinating School appoints a Supervisory Committee according to paragraph 5, section a, of Article 12 of Law 2083/92. This committee, in collaboration with the postgraduate student, defines the subject of the thesis to be undertaken.

3. Doctoral Candidates may provide paid teaching and research assistance in accordance with the rules approved by the Senate.

2.1.4 Specializations and Curriculum of MSc Program

The MSc Program "Automation Systems" offers the following two specializations:

SPECIALIZATION A: Manufacturing and Production Systems

Graduates of Specialization A will have expertise in Manufacturing and Production Systems, with a particular emphasis on the integration of automation and the support of all related processes through computer systems.

SPECIALIZATION B: Automatic Control and Robotic Systems

Graduates of Specialization B will specialize in Automatic Control and Robotics Systems, focusing on advanced robotic setups and advanced automatic control systems.

2.1.4.1 Curriculum

SPECIALIZATION A: Manufacturing and Production Systems					
TABLE OF OBLIGATORY COURSES					
Courses Semester A		ECTS	Courses Semester B		ECTS
1107	Design of Control Systems	5	1106	CAM and Applications	5
1108	Modelling and Control of Dynamical Systems	5	2206	Sensors	5

TABLE OF ELECTIVE COURSES (*Mandatory selection of 4* ***courses per semester***)					
Courses Semester A		**ECTS**	**Courses Semester B**		**ECTS**
1101	Optimal Production of System Design	5	1201	Transportation Systems	5
1103	Industrial Installations	5	1202	Anti-pollution Processes and Techniques	5
1104	CAD & Applications	5	1203	Welded Structures	5
1105	CAE & Applications	5	1204	Electrical-Mechanical Installations	5
1109	Technologies and Applications of Additive / 3D Printing	5	1205	Polymer Technology	5
1110	Advanced Manufacturing Systems (CIM-INDUSTRY 4.0)	5	1207	Energy Systems in Buildings and Industry	5
1206	Smart Materials	5	2204	Mechatronic Systems	5
		5	2103	Measurements	
Total of ECTS of semester		30	Total of ECTS of semester		30
Semester C			**ECTS**		
Postgraduate Diploma Thesis Completion			30		

SPECIALIZATION B: Automatic Control and Robotic Systems					
TABLE OF OBLIGATORY COURSES					
Courses Semester A		**ECTS**	**Courses Semester B**		**ECTS**
1108	Modelling and Control of Dynamical Systems	5	2202	Nonlinear Systems and Control	5
2104	Robot Control Systems	5	2205	Robotics Laboratory	5
TABLE OF ELECTIVE COURSES **From Specialization A:** *Mandatory Selection of* ***2*** *courses* ***in total****, i.e., either* ***1*** *per term, or* ***2*** *in either of the 2 semesters taken from Direction A courses as they appear in the table above and are not included in this table.* **From Specialization B:** *Mandatory Selection of* ***3*** *courses per semester.*					
Courses A΄ Semester		**ECTS**	**Courses B΄ Semester**		**ECTS**
1109	Technologies and Applications of Additive Manufacturing / 3D Printing	5	2103	Measurements	5
2203	Intelligent Control and Robotics Systems	5	2204	Mechatronic Systems	5
2201	Multivariable Control systems	5	2206	Sensors	5
1206	Smart Materials	5	2207	Adaptive, Robust and Hierarchical Control	5
2109	Seminar Course in Automatic Control and Robotics-1	5	2209	Seminar Course in Automatic Control and Robotics 2	5
Total of ECTS of semester		30	Total of ECTS of semester		30
Semester C			**ECTS**		
Postgraduate Diploma Thesis Completion			30		

All courses have a duration of three (3) hours per week. Depending on the availability of lecturers, it is possible to offer one or more additional elective courses (5 ECTS each), which will be relevant to the discipline of the MSc Program.

It should be noted that in the event of the inability to teach any of the aforementioned courses, the Postgraduate Studies Committee (PSC) has the ability to appropriately adjust the program, notifying the postgraduate students accordingly.

2.1.4.2 Course Selection Method

Each postgraduate student is required to attend and obtain a passing grade in: (i) the obligatory courses of their specialization, and (ii) elective courses as follows:

a. For Specialization A:
   i. In the 1st semester: four (4) courses.
   ii. In the 2nd semester: four (4) of the offered courses for Specialization A.
b. For Specialization B:
   It is mandatory to select two (2) courses from the Course List of Specialization A, either 1 per semester or 2 in any of the two semesters, which are not included in the course list of Specialization B. Additionally,
   i. In the 1st semester: three (3) of the offered courses for Specialization B.
   ii. In the 2nd semester: three (3) of the offered courses for Specialization B.

Therefore, to obtain the Diploma of Postgraduate Studies – Master of Science, a postgraduate student must accumulate ninety (90) ECTS credit, distributed as follows:

1st and 2nd Semesters: 60 ECTS (12 courses x 5 ECTS each = 60 ECTS)

3rd Semester: 30 ECTS (for elaborating and successful presenting the Postgraduate Diploma Thesis).

Accumulating ECTS credits from various MSc Programs does not lead to the awarding of a postgraduate degree.

2.1.4.3 Postgraduate Diploma Thesis (PDT)

a) Each postgraduate student has the right to undertake a PDT topic: (i) after the start of their second (2nd) academic semester, (ii) provided they have successfully passed six (6) out of the twelve (12) total courses required for graduation, (iii) at least four (4) months before the PDT presentation, and (iv) any undergraduate prerequisite courses specified by the Programme Steering Committee (PSC) must be successfully completed before undertaking the PDT. The completion of the PDT must not exceed the maximum duration of studies of the MSc Program, which is two (2) years from the date of first enrollment.

b) For postgraduate students who re-enroll in the subsequent year to attend courses of the 1st or 2nd academic semester, the Steering Committee (SC) decides on the possible undertaking of their PDT from the beginning of the 2nd academic year.

c) Each postgraduate student submits an application, which includes the proposed title of the PDT, the proposed supervisor, and a summary of the proposed thesis. Based on the application, the PSC appoints the supervisor and forms a three-member Examination Committee for the approval of the thesis. The Examination Committee includes the supervisor and at least one lecturer from the MSc Program from cases a) to f) of paragraph 1 of Article 83 of Law 4957/2022 and Article 5 of the present. The committee members must have the same or a related scientific specialty as the discipline of the MSc Program. Upon the supervisor's proposal, the postgraduate student can receive scientific support from PhD holders, PhD candidates, other postgraduate students, and other scientific collaborators from NTUA or invited lecturers outside NTUA. Additionally, members of the Special Teaching Staff, Laboratory Teaching Staff, and the Technical Laboratory Staff can participate in the laboratory support of the PDT, where necessary. The PDT grade is the average of the three examiners' grades on a scale of 1-10, rounded to the nearest half fraction, with a minimum passing grade of 5.5 (five and 50%). The PSC establishes uniform evaluation criteria.

d) The Postgraduate Diploma Thesis (PDT) text is composed using a word processor in a template approved by the Programme Steering Committee (PSC), and it must be submitted electronically, and in print form if requested by the Examination Committee and the NTUA Library. The PDT must include a summary of 1,200 to 2,000 words, a table of contents, bibliographic references, and a summary of 300 to 500 words in English. After the approval of the PDT, the postgraduate student is required to submit an electronic file of the thesis to the NTUA Central Library and electronically submit the thesis file to the NTUA Central Library's Digital Repository (dSpace). Approved PDTs are mandatorily posted on the MSc Program website.

e) The completion of the PDT must not exceed the maximum duration of studies of the MSc Program, which is two (2) years from the date of first enrollment. Therefore, if the PDT is not successfully completed within the third (3rd) academic semester, it can be continued in the next and final academic semester.

f) It is noted that for the awarding of the Diploma of Postgraduate Studies (DPS) – Master of Science, a passing grade is required both in the postgraduate courses and in the PDT.

2.1.5 Final Examinations

Final examinations are conducted one (1) week after the end of classes and other educational activities of each academic semester. The Steering Committee (SC) may, with a well-documented decision, allow an additional emergency examination for up to one-third of the courses per teaching semester if a postgraduate student was unable to take the exam due to reasons of force majeure.

2.1.6 Regulations for Courses Attendance, Examinations, and Diploma Grade

a) The MSc Program "Automation Systems" is full time, including the completion of the Postgraduate Diploma Thesis (PDT). For this reason, attendance of courses and participation in related educational activities and assignments is mandatory. Successful postgraduate students are required to follow an intensive curriculum lasting 12-24 months, with classes held both in the morning and afternoon, according to the schedule. In cases where up to five (5) postgraduate students attend a course, the lecturer has the discretion to decide whether to conduct the course. If there are exceptionally serious and well-documented reasons preventing the postgraduate student from attending, the Steering Committee (SC) may excuse certain absences, which cannot exceed one-third of the lectures. Otherwise, the postgraduate student has the right to retake the course (or another equivalent course designated by the SC) in the next and final educational period. It should be noted that if these reasons cause the postgraduate student to be absent for a longer period from educational activities, the student has the right to request a suspension of studies for a maximum of one (1) year, provided that the first academic year of studies has been completed. One (1) month before the end of the suspension period, the postgraduate student must apply to the MSc Program's Secretariat for re-enrollment (re-enrollment in the program is not "activated" automatically). Finally, it is noted that, exceptionally and in special cases, an extension of studies for a maximum of one (1) year may be granted, following a well-documented request, the supervisor's approval, and a reasoned decision by the SC, to complete their obligations for graduation.

b) Course grades are assigned on a scale of 0-10, without fractional parts, with a minimum passing grade of 5. The course grade is determined not only by the final examination but also by exercises, assignments, and other coursework conducted throughout the semester, with a relative weight set by the lecturer and not less than 30% of the total course grade. Only the PDT grade, given by the individual examiners and averaged, can include half fractional points, with a minimum passing grade of 5.5.

c) Results are issued by the lecturers within one (1) week of the final examination.

d) Students who fail a course may re-enroll in the same or different elective courses in the following year, upon application to the Steering Committee (SC), which will decide on a case-by-case basis. In the case of inter-university MSc Programs, according to paragraph 3.4., if re-enrollment is not feasible within the timeframe, an additional examination period may be exceptionally allowed, scheduled at an appropriate time by the PSC.

e) If a postgraduate student has attended courses from another recognized MSc Program and passed them successfully, they may be exempted from corresponding MSc Program's courses (up to three (3) at most) upon application, recommendation from the respective lecturers, and a decision by the SC. The student's application must include a detailed grade report from the other MSc Program and an official description of the corresponding course. The average course grades will be calculated accordingly.

f) In all cases, to be awarded the Diploma of Postgraduate Studies – Master of Science, the postgraduate students must achieve passing grades in both the postgraduate courses and the PDT. If this is not achieved within two years, the postgraduate student receives a certificate of attendance for the specific courses and exits the program.

g) The overall grade for the Diploma of Postgraduate Studies – Master of Science is calculated as the weighted average of the grades of the postgraduate courses and the PDT, where the latter is considered equivalent to the course credits of one semester. For example, for 12 postgraduate courses: Diploma Grade = (Sum of grades of 12 postgraduate courses + six times the PDT grade) / 18.

h) The numerical grade of the diploma is not printed on the original degree parchment; instead, only the qualitative scale "Good", "Very Good", or "Excellent" is indicated, based on the final calculated grade. The scales applied are the same as those for undergraduate studies: “Good” (5-6.99), “Very Good” (7-8.99), “Excellent” (9-10).

i) Those postgraduate students who successfully completed one of the specializations, as described in this Study Guide, are awarded the Diploma of Postgraduate Studies – Master of Science in the general field of “Automation Systems” with one of the following two specializations: “Manufacturing & Production Systems” and “Automatic Control & Robotics Systems”.

j) Once a year, specifically in October, the MSc Program’s Secretariat compiles a list of graduates, including those who successfully completed all requirements for graduation during the previous academic year. The degree is awarded in a special ceremony.

2.1.7 Language of instruction

The language of instruction is English; therefore a high level of English proficiency is required from the postgraduate students.

2.2 Courses list

1101. OPTIMAL PRODUCT AND SYSTEM DESIGN (5 ECTS)

Dimitrios Koulocheris, Prof. of School of Mechanical Engineering

Introduction to Engineering Design – Systematic Approach of Engineering Design. / Systematic conception of the structure. Decomposition of a structure into elements. Concurrent Engineering (CE) – Existing methods and tools of CE. / CE in optimal structural design. / Alternative Designs / Optimization in Product Design

After completing the course students will be able to:

- To identify different approaches of mechanical design.
- To analyse a product to its subsystems.
- To be aware of the existing alternatives to a subsystem design.
- To be able to apply the basic outlines of Mechanical Design Theory

Assoc. Prof. D. Koulocheris, Dr. Vosou C

1103. INDUSTRIAL INSTALLATIONS (5 ECTS)

Ioannis Antoniadis, Prof. of School of Mechanical Engineering

Lecture Topics:

Signal Theory:

- Basics of signals. Analog, discrete, and digital signals.
- Convolution, auto-correlation, and cross-correlation of signals.
- Modulated signals: amplitude, phase, and frequency modulation.
- Time windows.
- Time and statistical signal indicators.
- Sampling Theorem. Aliasing. Sampling parameters: scale factors (acceleration, velocity, and displacement), amplitude (Peak-to-Peak, RMS, etc.), number of samples and sampling period.
- Leakage and clarity in the time and frequency domains.

Vibrations and Fault Diagnosis:

- Maintenance Strategies: Corrective, preventive, and predictive maintenance.
- Introduction, basic concepts, fault isolation and identification.
- Vibration sensors (accelerometers, velocity sensors, etc.).
- Measurement and standards of vibration analysis.
- Calculation of basic fault frequencies.
- Diagnosis of faults in rotating machines with constant speed: basic concepts.
- Analysis/study of basic electromechanical faults: unbalance, misalignment, resonance, mechanical looseness, cavitation, faults in bearings and gears, and faults in induction motors.

Processing of Time Signals and Frequency Analysis:

- Processing of time signals and frequency analysis, Fourier series, and signal spectrum.
- Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT).
- Properties and limitations of the Fourier transform.
- Advanced signal processing methods for fault diagnosis in the time domain, frequency domain, and time-frequency domain:
  - Signal demodulation (Envelope Analysis) using the Hilbert transform.
  - Morphological Analysis.
  - Short-Time Fourier Transform (STFT).
  - Wavelet Transform.

Artificial Intelligence (AI) and Machine Learning (ML):

- Introduction to AI and ML.
- Differences between Machine Learning and Deep Learning.
- Supervised and unsupervised learning.

- ML for data and condition classification.
- Extraction/computation of features in the time domain (kurtosis, skewness, RMS, power, etc.), frequency domain (spectral kurtosis, spectral range, spectral mean, permutation entropy, etc.), and time-frequency domain.
- Properties of appropriate features. Standardization and normalization of features/data.
- Methods of selection (e.g., CDET-compensation distance evaluation technique) or reduction (e.g., PCA) of the number of features.
- Eigenvectors, eigenvalues, eigenvalue diagram, scree diagram, score, and loading diagram.
- Unsupervised Machine Learning methods: K-means, method analysis/study, proximity/similarity distances (e.g., Euclidean distance), random or non-random centroid selection. Advantages and disadvantages. Applications in the MATLAB computational environment.
- Supervised Machine Learning methods: Support Vector Machines - SVM, method analysis/study, Kernel functions, and study of linear and non-linear classification. Advantages and disadvantages. Applications in the MATLAB computational environment.
- Applications of Automated Data/Fault Classification.

Laboratory Demonstration Exercise:
The laboratory includes a demonstration of a small-scale experimental application related to fault diagnosis in a rotating machinery simulator of faults. Laboratory equipment (sensors, data recorders, etc.) is used to measure vibrations generated by the rotating machine. The specialized LabVIEW software used for designing information system architecture is presented and analysed. Vibrations are recorded and analysed in the time and frequency domains using Fast Fourier Transform (FFT). Additionally, data is processed using an envelope analysis method that uses the Hilbert transform. Differences in the spectrum for acceleration and velocity are studied.
Project/Research:
The project involves designing and developing an algorithm that simulates an automated fault classification system. Data (signals) recorded in an experimental setup in conditions of good operation, outer ring bearing wear, and inner ring bearing wear are used. The algorithm is developed in the MATLAB or Python computational environment. The algorithm includes feature extraction using signal processing methods, normalization or not of features, selection or reduction of features, training a classifier using Machine Learning methods, and checking the performance of the final code using test signals. In case the number of training signals for an 'operational condition' is limited, affecting the classifier's performance, there is the possibility of increasing them by applying a simulation model of these signals.
Upon successful completion of the work/research, students are expected to:

(A) Knowledge Level:
- develop and implement algorithms to solve scientific problems in the field of Engineering.
- familiarize themselves with contemporary methodologies for evaluating and comparing the performance of Machine Learning algorithms.
- clearly define the boundaries of a problem for resolution, fully recognizing its primary and secondary aspects, focusing attention on key points for its treatment.
- describe and argue the basic knowledge related to the topic of the research.

(B) Skills Level:
- critically and synthetically use available literature for the specific thematic area.
- design a research plan and develop an appropriate methodology for approaching and researching the topic under study, organizing the plan for its implementation.
- design, simulate, and/or construct prototype software in the computational environment of MATLAB or Python for the selected solution.
- compose a complete scientific/technical report.

• present conclusions, as well as knowledge and reasoning supporting them, clearly and effectively through ICT in front of the lecturer.

(C) Abilities Level:
• combine knowledge and utilize technical knowledge to solve complex problems in applications.
• select the appropriate techniques/approaches and adapt them to the problem faced with an original way of thinking.
• evaluate the approach/solution proposed, placing it in a comparative framework with similar work in Greek and international literature, and comment on its advantages and disadvantages, arguing personal views and choices.
• analyze results and draw conclusions.

Prof. I. Antoniadis , Dr. Ch. Giakopoulos

1104. CAD AND APPLICATIONS (5 ECTS)

Al. Ginnis, Assoc. Prof of School of Naval Architecture and Marine Engineering

Introduction. Bézier, B-spline, and NURBS curves and surfaces. Algorithms de Casteljau, de Boor, degree elevation, subdivision, and knot insertion. Geometric continuity between segments of curves/surfaces. Surfaces of quadrilateral, triangular, and mixed topology. Offset curves and surfaces.

The course aims to provide basic knowledge and develop fundamental skills in the area of computer-aided design. The foundational knowledge pertains to the structure of the geometric core of a modern CAD system and the methodologies and techniques of its development. Skills are cultivated through training students in a typical commercial CAD system and assigning them the completion of a design project for industrial objects of small/medium complexity within this system.

After completing the course students will be able to:

I. Understand a significant portion of the mathematical foundation of the geometric core of modern CAD/CAM systems.
II. Create three-dimensional geometric representations for industrial objects of small/medium complexity using the Rhino3D software system.

Al. Ginnis, Prof. of School of Naval Engineering

1105. CAE AND APPLICATIONS (5 ECTS)

E. Theotokoglou, Prof. of School of Applied Mathematical and Physical Sciences

The course includes:

• Generalization of the Finite Element Method, Methods of Weighted l Residuals,

Shape Functions in Finite Elements, Construction of shape functions, Shape functions in one-dimensional domains, Shape functions in two-dimensional domains, Plane elements, Beam elements, General element families, Mapped elements, Isoparametric mapping, Numerical integration.

The course aims to familiarize the students with the computational design of Mechanical Systems and the application of the methods through a project of their choice (after consultation with the lecturer).

After completing the course students will be able to:

I. To analyze engineering systems and complete the design of a complex arrangement with numerical methods.
II. To choose appropriate computational methods and procedures to analyze and solve modern engineering problems.

III. Be aware of the difficulties presented in the design and implementation of complex engineering systems and be able to work together in a team to deal with them.

IV. To be able to evaluate the basic technologies used in the design and operation of mechanical systems and their treatment with computational methods.

1106 CAM AND APPLICATIONS (5 ECTS)

P. Benardos, Assoc. Prof. of School of Mechanical Engineering

The course deals with the technology and programming of modern machine tools.

Machine tool structure and basic subsystems. Main concepts of machine tool dynamics. Main concepts of CNC systems (interpolation, axes motion control systems). Manufacturing cells and DNC controllers. G-code programming for turning and machining centres, bending and 3D printing (toolpath calculation, data flows, CAD file transfer, post-processors). CAPP (generative and variant process plans, design and drafting using process morphological features). Industrial robot programming (on and offline) for machine tool tending and processing. Evaluation of machine tool and industrial robot accuracy using laser interferometer (principles and implementation).

After completing the course, students should be able to:

I. understand the design of machine tool control systems and select appropriate components

II. program CNC turning and machining centres

III. develop CNC programs through the use of CAM systems

IV. program industrial robots for machine tool tending applications

V. understand CAPP procedures

VI. evaluate the various factors affecting machine tool accuracy

VII. implement metrology procedures for evaluating machine tool and industrial robot accuracy.

1107 DESIGN OF CONTROL SYSTEMS (5 ECTS)

G. Papalambrou, Assoc. Prof of School of Naval Architecture and Marine Engineering

Introduction to SAE. Signals, sensors, effectors.

Part A: Introduction to optimal control: Pontryagin, optimal quadratic regulator-LQ, Riccati equation. Optimal controller design. Observers.

Part B: Design of control systems using the Model Predictive Control (MPC) method. The control function of the two stages is explained: estimation of future state values and optimization over the future control horizon. Consideration of factors such as Single Input-Single Output (SISO) and Multi-Input Multi-Output (MIMO) systems, constraints imposed on controlled and control variables, systems with delays. A distinction is made between cases without restrictions, where the control function is close to that of the optimal quadratic regulator (LQR) and the case with limitations, where a real-time optimization problem is solved. The method includes a system model, so appropriate forms of mathematical models and system identification methods are presented.

Basic design and analysis is done in the time domain (continuous and discrete).

MATLAB/Simulink and Control Systems & Model Predictive Control toolbox are used in examples and applications.

There is mandatory LQ/MPC controller design work in a laboratory configuration with STM32 Nucleo F401 & MATLAB/Simulink microcontroller.

After completing the course students will be able to:

I. Design advanced predictive control systems (MPC), which are widely used in industry
II. Evaluate the operation of complex integrated control systems, including sensors and actuators
III. Implement predictive control systems using microcontrollers, prototype electronic circuits and related development software
IV. Make extensive use of MATLAB/Simulink and the Model Predictive Control toolbox through realistic examples in simulation and laboratory configuration.

1108 Modelling and Control of Dynamical Systems (5 ECTS)

X. Sarimveis, Prof. of School of Chemical Engineering

Methods of Modelling Dynamic Systems

This section presents the basic characteristics of dynamic systems and the mathematical tools used to model them, such as transfer functions, state-space representation, and Bode plots. It also presents methodologies for converting dynamic modelling from one form to another and methods for computing the dynamic response of systems to various inputs or disturbances.

Stability-Controllability-Observability

This section focuses on the concepts of stability, controllability, and observability, and the mathematical tools used to explore these properties in dynamic systems.

Characteristics of Dynamic Systems

Characteristics and criteria for stability and performance of control systems are presented in the time domain (such as rise time, overshoot, response time) and in the frequency domain (such as Bode and Nyquist diagrams and criteria, gain and phase margins, crossover frequency, peaks of frequency response and sensitivity).

Design of Control Systems that Meet Stability and Performance Specifications

The importance and modeling of feedback in the design of control systems are presented, along with a range of design methodologies that start with a brief review of classic methods such as Ziegler-Nichols and Cohen-Coon and extend to advanced methodologies like Internal Model Control (IMC), direct synthesis, and loop shaping.

Standardization of Uncertainty and Criteria for Robust Stability and Performance

Methods for quantifying uncertainty and incorporating it into the formulation and application of robust stability and performance criteria are presented. Students are also trained in the design of controllers that meet these criteria based on the methodology of mixed sensitivity.

System Norms and H2, H∞ Control Methods

The H2, H∞ control methods are presented based on the definition of norms, starting with vector norms and extending to matrix, signal, and system norms. Emphasis is given to explaining the theory and the mathematical optimization problems formulated for each method. The methodology of Singular Value Decomposition (SVD) and its importance in the analysis and design of control systems for multivariable dynamic systems are also presented.

Optimal Control

The methodologies of Linear Quadratic Regulator (LQR) and Linear Quadratic Gaussian (LQG) as specific cases of the H2 method are presented in detail. Emphasis is given to a specific methodology for calibrating LQR controllers that ensures good performance of the closed-loop system for multivariable systems. Finally, an introduction to Model Predictive Control (MPC) methodologies is provided, which are based on the discretization of dynamic systems and the incorporation of the problem's constraints into the objective function of the mathematical optimization problem solved in real time.

1109 Technologies and Applications of Additive Manufacturing / 3D Printing (5 ECTS)

Dr. St. Polydoras, (Laboratory Teaching Staff of School of Mechanical Engineering)

The course includes the following:

- Historical evolution of relevant technologies, distinction, categorization, main technologies
- Steps of the overall AM/3D Printing process
- Feedstock materials & selection between available technologies & systems
- Relevant international standards, file types/protocols for AM, 3D Printing software
- Combination with other relevant/complementary modern digitally supported technologies & processes
- Tooling preparation, assistance of industrial production
- Major and secondary utilization & application fields, impact on modern technical operations, possibilities and perspective of exploitation in the local technical and business environment
- Application examples

Within the context of this course, 3D printing software preparation exercises, as well as, use of desktop FFF/FDM 3D Printers are performed, leading to a graded personally submitted field-oriented essay. Also, semester-long projects contributing to the overall grade are electively assigned to student groups of three.

After completing the course students will be able to:

- properly use AM/3D Printing terminology

- successfully identify and classify AMsystems and equipment
- properly select specific technology and AM material class for given applications
- specify and use appropriate AM feedstock materials, in accordance with available equipment and intended application
- search and apply relevant AM standards, according to the nature and requirements of need/application in hand
- properly configure, export, exchange and use the appropriate electronic files/protocols for AM applications,
- successfully use AM process preparation software
- successfully complete the full cycle of an AM processes on a desktop scale, with MEX-TrB class 3D printers according to ISO/ASTM 52900:2022 (FDM/FFF technology)

1110 Advanced Manufacturing Systems (CIM-INDUSTRY 4.0) (5 ECTS)

G.X. Vosniakos, Prof. of school of Mechanical Engineering

I. Typology and structure of manufacturing systems. Modern Manufacturing Systems: flexible, reconfigurable and intelligent. Typical structure: machine tools, robots, sensors, mechatronic systems, controllers, databases, knowledge bases, local networks.
II. Flexible Manufacturing System Control based on Petri Nets: classic, timed, coloured. Fundamental theory and applications in discrete event control.
III. Integrated Manufacturing Systems (CIM) and their functional units. Information flow between functional units. Information interfaces. Main notions of networks: OSI model. Main notions of databases: generalized conceptual schema.
IV. Introduction to Industry 4.0 philosophy and technologies: Cyber-physical systems, Digital twins, Internet of Things, Virtual Reality, Machine Learning. Application domains: manufacturing process setup, process monitoring, tool / machine condition monitoring, Manufacturing Execution System – MES level.

After completing the course students will be able to:

- Analyse modern trends for flexibility in Manufacturing Systems.
- Design manufacturing system controllers using Petri Nets.
- Design data interfaces of functional units in CIM systems.
- Appreciate individual Industry 4.0 technologies and analyse predominant application domains.
- Implement Industry 4.0 applications using existing software platforms at the MES level.

1206 Smart Materials (5 ECTS)

Dimitrios Manolakos, Prof of the School of Mechanical Engineering

G. 1. Definition and classification of smart materials and systems.
H. 2. Correlation of microstructure with intelligent behavior of materials.
I. 3. Piezoelectric and Electrostrictive Materials.
J. 4. Magnetostrictive materials.
K. 5. Shape Memory Alloys and Magnetic Shape Memory Materials.
L. 6. Electrorheological and magnetorheological fluids.
M. 7. Technology of sensors, actuators and converters based on smart materials.
N. 8. Main technological applications of smart materials.

After completing the course students:

- will have deepened their knowledge in the field of materials and advanced materials
- will have acquired specialized knowledge on the mechanisms related to the various aspects of material intelligence and relevant systems

- will be able to analyze / evaluate / implement integrated intelligent structures applicable to various advanced technological sectors.

1201 Transportation Systems

Dimitrios Koulocheris, Prof of school of Mechanical Engineering

Transportation systems – Modeling of transportation systems – Transport Economics. / Freight Transport – Road & Railway transport – Statistics. / Safe transportation of dangerous goods (ADR, RID, IMDG). / Green & Intelligent transport. / State of the art in vehicles technology.

After completing the course students will be able to:

- To identify typical transportation systems.
- To understand road, rail, sea and air transportation and identify their restrictions.
- To be aware of the harmonization - implementation of European Directives in the field of transport.
- To be able to evaluate typical technical characteristics of superstructures.
- To be aware of the state of the art in the field of transportation systems.

1202 Anti-pollution Processes and Techniques (5 ECTS)

Maria Loizidou, Prof of School of Chemical Engineering

The course covers the following:

- Policy framework for the management of waste
- Sources, classification and characteristics of waste
- Reuse repair recycling circular economy symbiosis concepts and examples
- Sorting, temporary storage and transportation of waste & examples,
- Biological treatment of waste & case studies
- Thermal Treatment of waste & case studies
- Hazardous waste management and disposal of waste
- Field trip to an existing waste management facility

After completing the course students will be able to:

- Gain knowledge of the policy framework concerning the management of waste
- Identify the quantitative and qualitative characteristics of waste.
- Evaluate the quality of the environment and prevailing environmental conditions.
- Determine the environmental effects resulting from the disposal of waste.
- Assess waste management issues
- Propose methods for sustainable waste management

1203 Welded Structures (5 ECTS)
Assoc. Prof. K. Tzafestas School of Electrical Engineering and Computer Engineering

i. Basic principles of welding Metallurgy.
ii. Welding thermal cycle and relevant metallurgical phenomena (welding zones, phase transformations, microstructure evolution etc.) and residual stresses.
iii. Arc welding techniques (e.g., TIG, MIG), beam welding (laser, electron beam) and solid-state welding methods/techniques (e.g. friction stir, ultrasonic, diffusion).

iv. Protective atmosphere, available protection means (gasses, powders, slags etc.)
v. Current and voltage, main equipment & techniques

vi. Main welding defects and non-destructive testing techniques, weldment control

vii. Health & safety

1204 Electrical-Mechanical Installations (5 ECTS)

Vasileios Spitas, Prof of School of Mechanical Engineering

Building insulation, design of heating-cooling systems, ventilation, water supply systems, sanitation systems, elevators and lifting machines, electrical installations.

After completing the course students will be able to:

- Apply the standards pertinent to designing electrical and mechanical installations in buildings in Greece
- Compose a report with technical drawings

1205 Polymer Technology (5 ECTS)
P. Tarantili , Prof of School of Chemical Engineering

This course includes the presentation of basic concepts related to Polymer Technology. A brief reference is made on the synthesis processes and physicochemical characteristics (thermal transitions, crystallinity) of polymers. A presentation of the basic principles which control the rheology/rheometry of polymer melts follows, as well as of the molding procedures, with special emphasis on the recommended operating conditions for polymer processing and their optimization. Finally, through some Case Studies, various modern applications are investigated in the field of biomedical polymers, nanostructured polymers and food packaging. Reference is also made to some types of "smart polymers" suitable for applications as sensors/actuators.
After completing the course students will be able to:

- Handle and resolve technical problems on the design and control of polymers production and plastic moulding processes.
- Become familiar with the design and development of new and innovative products (i.e. sensors, actuators) based on polymeric materials.

1207 Energy Systems in Buildings and Industry (5 ECTS)
Maria Founti, Prof of School of Mechanical Engineering
a) Introduction; (b) Building Energy Systems (MEPs, Automation Systems, Metering, Energy Saving measures, Visit/measurements in a pilot building); (c) Energy Systems in Industry (Combustion Technologies, Cogeneration Heat/Electricity, Auxiliary Industrial Systems, Case Studies); (d) Heat/Electricity Storage (Systems and Applications)
The course aims to equip students with specialist knowledge in the technical and operational characteristics of:
(a) power generation systems
(b) thermal and electrical storage systems
(c) automation systems of energy devices and facilities
with the aim of energy saving

2204 Mechatronics (5 ECTS)

E. Papadopoulos, Prof of School of Mechanical Engineering

Introduction, design, modeling, parameter identification & analysis, sensors, actuators, mechanisms, transmissions, analog electronics, A/D & D/A, microcontrollers (h/w & s/w), single board computers, real-time PLC (RTOS), control, construction issues. The course aims to familiarize the students with the design of Mechatronic Systems and the application of the methods through a project of their choice (after consultation with the lecturer). After completing the course students will be able to:

- To analyze mechatronic systems and complete the design of a complex arrangement.
- To choose appropriate technologies of sensors, actuators, electronics, microcontrollers, for use in mechatronic devices.
- Be aware of the difficulties presented in the design and implementation of complex mechatronic systems and be able to work together in a team to deal with them.
- To be able to evaluate the basic technologies used in the design and operation of mechatronic systems.

2203 Measurements (5 ECTS)

Ioannis Gonos, Prof. of school of Electrical engineering and Computer Engineering

Brief reference to the history of measurement. Structure and organization of modern metrology. Error Analysis, instrumentation, classical electric measurement methodology, oscilloscopes, nullitying instruments (bridges and compensation apparatus). Energy and power measurement of one-plase and multi-phase systems. Open loop and closed loop amplifiers, operational amplifiers, measurements on operational amplifiers. Analogue measurements of electrical quantities, digital multimeter (voltmeter, ammeter, ohmmeter), analogue measurements of non-electrical quantities, converters, force and torque measurement. Theoretical and statistical foundation of uncertainty. The assessment of uncertainties in practice. Measurement – Uncertainty – Decision rule. After completing the course students will be able to:

- Know the function of the basic elements of instrumentation
- Carry out measurements with the basic equipment of classical electrical measurements
- Calculate the various errors that occur during the measurement process and the uncertainty of a measurement.
- Evaluate the conformity or not of a product through measurement, uncertainty and using the decision rule.

2206 Sensors (5 ECTS)

E. Christoforou, Prof. of school of Electrical engineering and Computer Engineering

1. Basic principles of sensors: sensitivity, uncertainty, hysteresis, linearity, parameters affecting the sensor response, sensor characterization techniques, Laboratories of Testing and Calibration.
2. Physical & chemical phenomena, used for sensor operation: phenomena in conducting, semiconducting, dielectric, magnetic and superconducting materials.
3. Sensors: Mechanical sensors (displacement, position, velocity, acceleration, flow, force, tensile & compressive stresses, pressure), electric-magnetic sensors (electric current, electric field, magnetic field, magnetic anomaly detection), thermodynamic sensors (temperature, humidity, moisture), chemical sensors (ISFET).
4. Sensor applications: energy & environment, health, safety & security, defense, industrial applications, system automation, domestic applications etc.

Lab:
1. Calibration of a Hall sensor
2. Magnetic sensors for position and field measurements
3. Arduino and applications (Part A)
4. Arduino and applications (Part B)

After completing the course students will be able to:

- Select the proper physical solution for a given application.
- Design the development of the sensing element for a given application.
- Develop and calibrate the sensor for a given application.

2104 Robot Control Systems (5 ECTS)

Kostas Tzafestas, Assoc. Prof. of school of Electrical engineering and Computer Engineering

The main objectives of the course are: a) to introduce the students to the basic concepts and topics of Robotics, mainly regarding the analysis and control of classic robotic manipulators, systems which are widely used in a variety of industrial (and other) applications, and b) to familiarize the students with the analytical mathematical tools involved in the study of classical industrial robotic manipulation systems, as well as to help students assimilate and understand the functionalities and the control methods of a robotic system.
The contents of the course are organized in 3 main sections:

1. Kinematic Analysis of Robotic Manipulators
- Forward and inverse kinematic analysis – Geometric model
- Differential kinematic analysis – Forward and inverse – Jacobian matrix
- Robotic manipulation systems with kinematic redundancies
2. Static and Dynamic Analysis of Robotic Manipulators
- Study of forces and moments
- Compliance matrix of a robotic manipulator
- Newton-Euler and Lagrange formulations of robot dynamics
- Direct and inverse dynamics
- Robot dynamic parameter identification
3. Motion Control of Robotic Manipulation Systems
- Robot trajectory design – Robot motion planning
- Joint space linear control – Local joint PD control
- Model-based nonlinear dynamic control; Computed-torque control
- Operational space control
- Adaptive and Robust control of robotic systems

After completing the course students will be able to:

- Recognize and describe the basic structural elements and functionalities of a robotic system
- Model and analyze mathematically robotic manipulators of serial kinematic structure, systems that are widely used in a variety of industrial applications
- Design, with respect to its analytical structure, the control system of a robotic manipulator and evaluate its performance
- Select the appropriate method for the design of a robot trajectory to execute complex robotic manipulation tasks
- Implement appropriate computational tools for simulating the operation of a robotic manipulation system and for visualizing the results
- Be aware of the challenges associated with the design and implementation of a control system for robotic manipulators
- Evaluate the basic technologies used in the design and operation of robotic manipulation systems

2203 Intelligent Control and Robotics Systems (5 ECTS)

Ch. Bechlioulis, Assoc. Prof. of University of Patras

Introduction to Intelligent and Adaptive Control – Heuristic Adaptive Control Techniques (MIT-RULE κλπ)

– LYAPUNOV Theory – Model Reference Adaptive Control for Nonlinear Systems – Robust Adaptive

Control for Robotic Manipulators (model based) – Neuro-adaptive Control – Hands on Lab on Robotic Manipulators,

After completing the course students will be able to:

- Model and study dynamical systems.
- Implement basic online schemes of parameter identification.
- Design basic adaptive control schemes.
- Simulate the operation of adaptive control schemes in various application domains.

2201 Multivariable Control systems (5 ECTS)

Dr. A. Soldatos, Special Teaching Staff of the School of Electrical engineering and Computer Engineering

Multivariable Control Systems in state space. Elements of Abstract Algebra and Differential Geometry. Optimal Control, Robust, Multivariate Control. The problem of control in many-input (stimuli) many-output (response) systems. Linearization of a system in the region of an equilibrium point. System time response and ways to calculate the matrix exponential function. Definition and properties of transfer function matrix. Controllability, observability and Kalman decomposition. Controllability indicators and system observability indicators. Equivalence of polynomial matrices. Forms of matrix. Zeros at infinity and finite system zeros. Generalization of the root locus method in multivariable systems and the role of zeros at infinity. Normal form Popov. Luenberger normal form. Normal observable form. Theory of polynomial matrices. Introduction to the system matrix. Transformation of the system matrix. Controllability and observability of system matrix description. Introduction to Lyapunov stability for nonlinear and linear systems. After completing the course, students will be able:

1. To describe a multivariable system in the time or the frequency domain.
2. To decide on the response specifications of a system and design an appropriate controller.

2202 Nonlinear Systems and Control (5 ECTS)

Iason Karafyllis, Prof of School of Applied Mathematical and Physical Sciences

Stability notions for dynamical systems. Lyapunov functions for dynamical systems. The state feedback stabilization problem for control systems. Backstepping for triangular nonlinear control systems. Control Lyapunov Functions and the Artstein-Sontag Theorem. Control Lyapunov Functions for nonlinear triangular control systems. Input-to-State Stability. The observer problem for control systems. The output feedback stabilization problem for control systems. High-Gain observer design for globally Lipschitz nonlinear systems.

After completing the course, students will be able to:

- design nonlinear state feedback stabilizers for various classes of nonlinear control systems,
- design nonlinear observers for various classes of nonlinear control systems,
- design nonlinear output feedback stabilizers for various classes of nonlinear control systems, and
- understand stability notions for dynamical and control systems.

2205 Robotics Laboratory (5 ECTS)

Kostas Tzafestas, Assoc. Prof. of school of Electrical engineering and Computer Engineering

The main objectives of this course are to help students: 1) acquire practical knowledge and skills through laboratory exercises, and 2) assimilate the corresponding theoretical knowledge on motion planning, control and programming of robotic systems (mainly industrial-type robotic manipulators and robot-integrated automated production systems).

The laboratory exercises, for the practical understanding of the functionalities and control modes of robotic systems, include the following: 1) Linear control of a single robotic joint, 2) Programming of a robotic production process (robot cell), 3) Elements of linear and nonlinear control with application to articulated robot arms (such as the Pendubot, a two degree-of-freedom inverted pendulum setup), 4) Programming techniques for an industrial-type robot arm (e.g. Adept Scara-type), 5) Motion programming of a small collaborative robot arm (a six degree-of-freedom Cobot) performing a pick-and-place task.

The contents of the course also include familiarization (through the preparation of a team project) with specialized programming tools for the development of software applications to perform motion planning and control of robotic systems using ROS (Robot Operating System) as the software platform. After completing the course students will be able to:

- Recognize and describe the basic structural elements and functionalities of an integrated robotic system
- Decompose a complex robotic manipulation task into elementary motion control steps
- Synthesize a program for the execution of a robotic manipulation task
- Design the controller of a robot manipulator arm incorporating modules for the compensation of static and dynamic positioning errors
- Select the appropriate method for the design of a robot trajectory to execute complex robotic manipulation tasks
- Implement appropriate computational tools for programming a robot manipulator task and for simulating its operation
- Be aware of the challenges associated with the design and implementation of a control system for robot manipulators
- Evaluate the basic technologies used in the design and operation of robotic manipulation systems

2207 Adaptive, Robust and Hierarchical Control (5 ECTS)

H. Psyllakis, Ass. Prof. of school of Electrical engineering and Computer Engineering

Introduction to adaptive and robust control, Lyapunov stability theory, Lyapunov stabilizing controllers, model-based controllers, sliding mode robust control, model reference adaptive control (MRAC), Self-tuning regulators, introduction to hierarchical and decentralized control, open and closed-loop hierarchical control, nested hierarchical control, decentralized control of large-scale systems. After completing the course students will be able to:

- To demonstrate a deep understanding of identification methods
- To fully comprehend the adaptive, robust and hierarchical control methods.
- To design adaptive, robust and hierarchical controllers for linear/nonlinear dynamical systems.

2.3 Information for Students

Information on the following topics is available on the NTUA website: https://www.ntua.gr/el/, (services), and specifically at the links:

- https://www.ntua.gr/el/services/facilities-for-students
- https://www.ntua.gr/el/services/facilities-for-members

The following topics are covered:

- Cost of living
- Housing
- Dining
- Medical services
- Services for students with special needs
- Insurance / Healthcare
- Financial support for students
- Student Affairs Office – Academic advisors
- Study rooms – Reading rooms – Libraries
- International programs
- Practical information for mobile students
- Language courses
- Internships
- Sports facilities
- Extracurricular and leisure activities
- Student associations