

**IMT School PhD Programs in “Cognitive and Cultural Systems”,
“Economics, Analytics and Decision Sciences”
and in “Systems Science”**

**Call for applications 2022/2023
Executive Summary**

PHD PROGRAMS DESCRIPTION

The IMT School for Advanced Studies Lucca has launched the call for applications for the PhD Programs in “Cognitive and Cultural Systems”, “Economics, Analytics and Decision Sciences” and “Systems Science” (2022/2023 academic year) – descriptions attached.

The IMT School adopts equal opportunity principles in its selection procedures and rejects any type of discrimination based on sex, gender identity, nationality, ethnicity, religious belief, sexual orientation, state of health, and any other status or quality that is not strictly relevant to the call outlined in this document.

Program official duration: 3 years.

Programs start on November 2nd, 2022.

PhD Program Coordinators:

- PhD Program in “Cognitive and Cultural Systems”: Prof. Maria Luisa Catoni;
- PhD Program in “Economics, Analytics and Decision Sciences”: Prof. Ennio Bilancini;
- PhD Program in “Systems Science”: Prof. Alberto Bemporad

Program official language: English.

Scholarships: 32 (distributed among PhD Programs as follows)

PhD Program	Scholarships
Cognitive and Cultural Systems	14
Economics, Analytics and Decision Sciences	8
Systems Science	10

The number of positions may be increased in the event that additional funding is made available after the publication of the Call.

Scholarship gross amount: 16,243.00 Euros/year (see the “Scholarships” paragraph).

Additional benefits:

- All PhD students admitted to the PhD Program are exempt from paying tuition fees, although they are still responsible for paying the yearly Regional Education Tax (currently 140.00 Euros/year);
- All PhD students are offered free meals (lunch and dinner) at the on-campus canteen;
- All PhD students are provided with free accommodation in shared double rooms within the campus residential facilities.

REQUIREMENTS

Applications are open to candidates who meet the following requirements:

1. Degree:

- "Laurea Magistrale" or "Specialistica" (according to DM no. 509, of November 3, 1999), or a four- or five-year degree (according to the previous rules of the Italian higher education system) obtained in Italy;
- Foreign degrees with a minimum duration equivalent to 4 years (full time). The 4-year duration should be considered a minimum but not sufficient requirement: the Selection Committees will assess the eligibility of degrees.

For the selection procedure, candidates are required to upload the documents indicated in Table 2 - Attachments to the application.

Applicants who obtain their degree by no later than **October 31st, 2022**, can also apply. These candidates will be admitted to the selection procedure "with reserve" and must provide their degree certificate by the date of enrollment, or they will be excluded from the program.

2. Knowledge of the English language: Applicants are required to indicate their level of English.

APPLICATION

The **application form** must be **mandatorily** filled out in **English** through the School's online procedure

- **by June 30th, 2022, at 12:00 pm (CEST)** for the PhD Program in "Economics, Analytics and Decision Sciences";
- **by July 27th, 2022, at 12:00pm (CEST)** for the PhD Programs in "Cognitive and Cultural Systems" and "Systems Science".

Applicants must upload the **documents** in **PDF**. The **maximum size is 30MB** for each attachment.

The Selection Committee will accept **attachments** in **Italian or English only** (unless otherwise specified in the table below).

Table 1: Information

Track	compulsory	It is possible to apply for more than one track, submitting a new application for each track selected. Applicants cannot register more than once with different email addresses and/or different names or submit more than one application for the same track (in this case, only the last one will be considered valid).
Personal information	compulsory	In this section, applicants must enter their personal data (name, address, contact details, etc.).
English Language Level	compulsory	Applicants must indicate their level of English.
Additional information/Interview	compulsory	Applicants have to indicate the modality for the interview (IMT School campus, videoconference, or similar, or by telephone at an Italian embassy/consulate).
Additional information/Disability	optional	Applicants should indicate if they need assistance to participate in the selection procedure.
Additional information/How did you first find out about IMT?	compulsory	Applicants are required to indicate how they found out about the IMT School.
Education	compulsory	Applicants are required to indicate their university degrees (whose duration must be equivalent to at least 4 years of university studies), the average exam mark, and final grade (if any) for each degree obtained.
Additional qualifications	optional	In this section, applicants may list any other qualifications considered relevant in relation to their application.
Publications	optional	Applicants can list their own published articles, books, or any material that may be considered relevant for the PhD and research activity.
References	compulsory	Applicants are required to provide the names and contact information of two referees. The referees who are invited to submit a reference letter in English through the IMT School's online application system, - by July 7th, 2022, at 12:00 pm (CEST) for the PhD Program in "Economics, Analytics and Decision Sciences"

		- by August 3rd, 2022, at 12:00 pm (CEST) for the PhD programs in "Cognitive and Cultural Systems" and "Systems Science", will receive an automatic notification from the School's application system. Applicants will receive an automatic notification when a letter is submitted, but they may not access any reference provided.
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Table 2: Attachments			
1	Copy of National Identity Card or Passport	compulsory	Applicants have to upload a copy of a valid identity document: - For Italian and EU citizens: Valid National Identity card or Passport - Non-EU applicants: National Identity card or Passport (the latter is highly recommended). The copy has to be signed by the candidate, indicating the date and place of the signature. In particular, the document has to contain the applicant's photograph, personal data, and document number, place and date of issue. If any of the above information is missing, the document will not be accepted. If the document is not in English or Italian, a translation into English or Italian should also be uploaded (an official/legal translation is <u>not</u> required). In the event that the copy of the document is unreadable, the Selection Committee may request a new submission.
2	Curriculum vitae et studiorum/Resume	compulsory	Applicants must upload their curriculum vitae et studiorum/resume in Italian or English (the latter is highly recommended), indicating their university degrees, work and research experience, and publications (if any).
3	Education	compulsory	Candidates are required to upload one of the following documents in Italian or English: - for degrees obtained in Italy and/or in France, Ireland, Belgium, Denmark (Bruxelles Convention of May 25, 1987), and Germany (Italian-German Convention, ratified by the Law no. 176 of 1973): a self-declaration stating the possession of a degree, conferral date, issuing University, and final grade; - for degrees obtained in all other EU and non-EU countries: an official certificate indicating the possession of a degree, conferral date, issuing University, and final grade.

4	Academic transcript/Diploma supplement	compulsory	For each degree, the applicant has to attach one of the documents listed below in Italian or English (English is highly recommended): • Academic transcript: an official document detailing the course, classes attended or subjects studied and results, completion date, graduation date; <u>or alternatively,</u> • Diploma Supplement: document produced by the University accompanying the diploma, providing a standardized description of the nature, level, context, content, and status of the studies completed by the applicant (https://ec.europa.eu/education/diploma-supplement_en).
5	Research Statement	compulsory	To best evaluate each candidate's aptitude for the School's PhD Programs, all candidates must upload a document (maximum 10,000 characters, spaces included) mandatorily in English, as specified below for each track: • for AMCH: the research statement consists of a research project proposal used exclusively to evaluate the application. Once admitted to the Program, candidates will define their research project with their assigned Advisor. A letter of commitment, including future projects and motivation for enrolling in the AMCH track at the IMT School, is also required; • for CCSN: the research statement must include a description of the candidate's competencies and experiences within the relevant scientific or academic field, future projects, and an illustration of the candidate's motivation for pursuing study at the IMT School; • for EADS: the research statement must include a summary of the candidate's academic background, scientific interests, research experience, research ideas for future projects, and motivations for pursuing a PhD in Economics, Analytics and Decisions Sciences at the IMT School; • for MUSST: the research statement consists of a description of the candidate's experiences, and a letter of commitment including future projects and motivation for enrolling in the MUSST track at the IMT School; • for Sys: The research statement must include a summary of the candidate's academic background, scientific knowledge, research experience, ideas for future research projects, and motivations for pursuing a PhD study at the IMT School.

If the application lacks a piece of information or an attachment referred to as "compulsory", applicants can be conditionally admitted to the selection procedure. Their application will be considered valid only if they produce the required documents by the day scheduled for the interview.

The correct completion of the online application procedure is **confirmed by an automatic email** sent to the email address indicated by each applicant while registering for the procedure; the message only confirms the receipt of the application. The School will not verify the validity and completeness of applications before the call closes.

After the submission, no changes are allowed to the entered data.

SELECTION COMMITTEES

The Selection Committees are nominated by decree by the Director of the IMT School in accordance with the School regulations.

The Selection Committees may be assisted by Preliminary Evaluation Committees, which are also nominated by the Director and can comprise IMT School Professors, Assistant Professors, Post-Doctoral Fellows, or experts from relevant fields.

EVALUATION CRITERIA AND SELECTION PROCEDURE

Evaluation criteria

The Selection Committees will evaluate candidates'

- academic background, knowledge, skills, and scientific potential;
- general aptitude for research and potential to collaborate in the specific research activities of the selected Track in the application form;
- interdisciplinarity, knowledge, and skills with reference to the multidisciplinary of the IMT School PhD Programs;
- pertinence to a track different than the one selected in the application form.

Assessment of qualifications

The first phase of the selection procedure is the assessment of qualifications. This assessment is carried out in relation to the specifics of the PhD Programs and specifically to determine who is admitted to the interview.

In the assessment of qualifications phase, the evaluation of the candidates is carried out by the Committees defined in the previous paragraph "Selection Committees" and based on the candidates' application form, uploaded documents, and reference letters provided by referees.

Based on the assessment of qualifications, the Selection Committees will draw up a shortlist of candidates admitted to the interview in alphabetical order.

The shortlist of applicants admitted to the interview will be published on the School's website and Online Notice Board ("*Albo Online*").

This is the only official communication of the preliminary results to all applicants.

Interview

Candidates admitted to the interview must confirm their participation by email to phdapplications@imtlucca.it within two (2) days of the publication of the shortlist, confirming their preference to have the interview conducted in one of the methods indicated in the "Application" paragraph of this call.

During the comprehensive interview, the Selection Committees will assess the candidates' knowledge and skills with reference to the specific characteristics of the PhD Program.

The Selection Committees will assess all interviews by assigning a score (up to 100 points): applicants scoring at least 70 out of 100 will be eligible for the Program and, therefore, listed in the final ranking.

Final ranking

At the end of the interviews, each Selection Committee will draft the final ranking of the eligible candidates for each track/PhD Program according to their scores obtained in the interview.

If multiple candidates get the same score, preference will be given to the youngest candidate.

In the event of the withdrawal or exclusion of a candidate, they shall be replaced by the next suitable candidate according to the ranking.

If the ranking of a track does not list enough eligible candidates to allocate all available positions, the remaining scholarships will be assigned according to the ranking of other eligible candidates of the other PhD Program's track.

All rankings will be published on the School's website and Online Notice Board ("*Albo Online*").

ENROLLMENT

Once admitted to the PhD Program, candidates wishing to enroll must submit the complete enrollment form to the IMT School **no later than five (5) days from the publication of the results** on the School's Online Notice Board ("*Albo Online*") and website, using one of the following methods:

- in person or by post to:
IMT School for Advanced Studies Lucca
PhD and Higher Education Office
Piazza S. Ponziano, 6
55100 Lucca – Italy
- by fax to +39 0583 4326565
- by certified email to imtlucca@postecert.it

Failure to submit the enrollment request by the deadline and through the above-mentioned methods will result in an automatic withdrawal of the candidate from the Program.

The enrollment request is valid only if all the requested documents have been enclosed.

If any of the documents submitted during the application procedure do not correspond to those submitted during enrollment due to an intentional false declaration, the applicant will automatically lose their right to enroll in the program.

Enrollment is effective on the first day of official classes. Unauthorized absences may nullify the enrollment procedure.

SCHOLARSHIPS

The scholarship amount is 16,243.00 Euros/year and shall be disbursed in monthly installments.

For any research or training activities at universities or research centers abroad, the scholarship amount is increased by 50% for the first nine (9) months.

Scholarships are subject to the payment of social security contributions (INPS) managed separately under Article 2, paragraph 26 of Law no. 335 of August 8, 1995, as amended, with two-thirds paid by the Administration and one-third by the scholarship recipient.

Admitted candidates who have already benefited from a PhD scholarship in Italy cannot be assigned another one.

The scholarship has a maximum duration of three (3) years and is subject to annual confirmation: according to articles 15 and 16 of the IMT School PhD Regulations, students must complete all the activities provided for each academic year.

If a student withdraws or is excluded within 45 days from the beginning of the Program, they are not entitled to the scholarship. The scholarship will be awarded to the next eligible candidate according to the final ranking. For this reason, the first scholarship payment will be made only after the successful completion of the first 45 days of the program.

If a student registers after 45 days from the beginning of the Program, he/she is entitled to the scholarship starting from the actual date of enrollment.

FACILITIES

Residential facilities: accommodation

All PhD students who are granted a scholarship have free accommodation in shared double rooms with private bathrooms, priority being given to on-campus residential facilities, for the entire official duration of the Program (3 years), except for periods spent off campus for study and/or research.

The School can revoke the right to accommodation if it is rarely or not used.

Residential facilities: canteen

All PhD students are offered free meals (lunch and dinner) at the School canteen located on campus for the entire official duration of the Program (3 years). Lunch and dinner are served each day, Monday through Sunday, for the entire academic year, except for the closing periods.

Other facilities

All PhD students have access to library facilities and can benefit from the IT support services for all technical requests related to study and research until the thesis defense.

The School subscribes to an insurance policy for all PhD students. It provides coverage against accidents and injuries incurred by students in Lucca or abroad while performing academic activities. The IMT School also provides students with health insurance policies for research trips outside Europe (students are automatically covered in European countries).

All international PhD students are offered the possibility to take an Italian language and culture course to receive an A2 language certificate (as defined by the Common European Framework of Reference for Languages), useful for obtaining credits in accordance with Italian Immigration law.

TREATMENT OF PERSONAL DATA

The IMT School will use the personal data provided by applicants solely for selection procedures and institutional aims in accordance with the provisions of the current European and Italian legislation (EU Regulation 2016/679 and Italian D. Lgs. 196/03 - *Italian Privacy Code*, as modified by the D. Lgs. 101/2018) and the relevant School Regulations.

Applicants are granted all the rights established by art. 15, sections 2, 3, and 4 of Chapter III, and art. 77 of the EU Regulation 2016/679.

For further information regarding the call and the selection procedure, please contact the PhD and Higher Education Office by email at phdapplications@imtlucca.it or by phone at +39 0583 4326530.

Further information regarding the PhD Programs and the IMT School is available at www.imtlucca.it.

FINAL PROVISIONS

Having adopted all the necessary measures to carry out the activities planned for the 2019/20, 2020/21 and 2021/22 academic years, during the health emergency related to COVID-19, if the aforementioned emergency continues, the IMT School will provide the activities and services planned for the 2022/23 academic year in ways that allow new PhD students to enroll, attend education activities, and undertake their doctoral studies.

Relevant laws and the IMT School PhD Regulations shall be applied to any issue or item not covered by the present call for applications.

IMT SCHOOL PhD PROGRAMS AND TRACKS

	Description
PhD in "Cognitive and Cultural Systems"	The PhD Program in Cognitive and Cultural Systems unites disciplines that have been carefully selected for their ability to provide the necessary cultural, methodological and instrumental know-hows for the analysis of complex social, cognitive, psychological and cultural systems. It is truly a unique PhD Program thanks to its common topics of study that consist of cognitive, cultural and social systems. The Program proposes a distinction in three Tracks on the basis of the methodologies applicable to the study of the brain, perception, mind, knowledge organization, behaviors, human activities and productions, as well as their material and symbolic functions and representations, objects and spaces. This shared field of study that the three Tracks look at through diverse but complementary methodological, analytical and technical lenses, includes: conceptual representation against neurobiological and cultural backdrops; the contextual and multidisciplinary study of objects, images and spaces within defined historical, political, social ideological, economic, legal and cultural contexts; the study of the perception of and the interaction with the external world; the study of the reception of images and forms from a historical-cultural and neuroscientific point of view; the contextual study of cultural heritage in its multiple dimensions; the study of institution building through cultural heritage and the role of cultural heritage as an instrument of cultural diplomacy. It deals with, hence, relevant themes in a long-term perspective. The principal educational goal of the Program is that of providing students with a mastery of methodological tools and advanced techniques for neurosciences and for the analysis and management of cultural heritage, of cultural phenomena and their multiple impacts, with a focus on museums and museums studies. This Program is characterized by its interdisciplinary nature and by its innovative approach that, beyond training students in the specific areas of neuroscience and cultural heritage, deals with the study of the relation between historical-contextual analyses (including aesthetic and artistic analyses) and neuroscientific analyses and the study of the complex system made up by behaviors, activities and human productions from perspectives and with instruments that are both complementary and integrated. The Program is made up of three Tracks and, in the spirit of the School, integrates academic excellence with an interdisciplinary vocation. The Analysis and Management of Cultural Heritage (AMCH) Track offers different tools for the analysis of cultural heritage, i.e., archaeology, art history, administrative law, philosophy, history, management science and new technologies. The Museum Studies (MUSST) Track, established in partnership with some of the main Italian museums and cultural institutions, offers different tools for the analysis of museums and related issues, such as object display, curatorship, temporary and permanent exhibitions. The Cognitive, Computational and Social Neurosciences (CCSN) Track integrates a basic neuroscience training with the study of mental activities and cognitive functions in neuropsychological, psycholinguistic, computational, social, philosophical, logical and educational domains.

PhD in "Cognitive and Cultural Systems"

Track in "Analysis and Management of Cultural Heritage" (AMCH)

PhD in "Cognitive and Cultural Systems" Track in "Cognitive, Computational and Social Neurosciences" (CCSN)	Students will specifically receive intensive practical research training in methods, experimental design, and data analysis in the laboratories of the MoMiLab Research Unit. An overview of neuroimaging (mainly structural and functional MRI) and electrophysiology (EEG, MEG, and non-invasive brain stimulation) techniques will address research and clinical applications and their use in human subjects. Within the interdisciplinary orientation of the IMT School, students will be exposed to seminars and conjoint research projects on different topics, ranging from molecular neurobiology of human behavior to advanced computational methods for the analysis of complex systems, from social neuroscience to decision-making processes in economic systems, from neuro-engineering applications in bionics and robotics to complex networks, from the neural bases of perception and conceptual representation to the image analysis and management of cultural heritage. <i>Input and Output Profiles</i> Candidates with a solid background in psychology, neuroscience, cognitive science, medicine, bio-engineering, bionics, physics and mathematics, computer sciences, linguistics, philosophy, and logic are strongly encouraged to apply. Because of the multidisciplinary nature of this doctorate track, applications are anyhow welcome from any area of knowledge, including both scientific and social fields and humanities. According to our placement scores, graduates from this doctorate track will be able to pursue a career in research and academic institutions as well as in the private sector. <i>Research Units Contributing to the track</i> All the Research Units contribute to the track. Most of the experimental activities overlap with the research activities of MoMiLab. Students will have access to the Multidisciplinary Lab (equipped for EEG, psychophysics, and psychophysiology measures) and Neuroscience Lab (the conjoint research lab with Innovation Center Intesa Sanpaolo) at the IMT School, the Thematic laboratory for research on sleep, wakefulness, and their mutual interactions (equipped for polysomnographic measures) at the Fondazione Toscana 'Gabriele Monasterio' in Pisa and external MRI facilities (scanners from 1.5T to 7T are available in Pisa and Massa). Ph.D. students will also have the opportunity to be involved in collaborative research programs with national and international institutions, including the Piaggio Research Center at the University of Pisa, the Fondazione Toscana 'Gabriele Monasterio' in Pisa, the Sant'Anna School of Advanced Studies in Pisa, the University of Siena, the Department of Brain and Behavioral Sciences at the University of Pavia, the Department of Philosophy at the University of Milan, the Department of Psychology at the University of Turin, the Department of Psychology at the University of Padua, the CIMeC – Center for Mind/Brain Sciences in Rovereto, the Center for Consciousness and Sleep at the University of Wisconsin, the Institute of Psychology & Institute of Neuroscience - University of Louvain, the Massachusetts Eye & Ear at Harvard Medical School and the Center for Investigation and Research on Sleep of Lausanne University Hospital.
PhD in "Cognitive and Cultural Systems"	The track in Museum Studies is dedicated to museums and museum studies. Based on an institutional partnership between IMT and some of the most relevant Italian museums and cultural institutions (Museo Egizio di Torino, Galleria Nazionale di Urbino, Museo Nazionale Romano, Parco Archeologico di Pompei, Direzione Generale dei Musei), the track proposes course on public engagement, cataloguing methods, museum

Track in "Museum Studies" (MUSST)	management, museum visitors. PhD research will be developed in strong connection with the members of the above-mentioned partnership. <i>Input and Output Profiles</i> The track aims at providing specific know-how to prospective professionals operating in the fields of museums, providing deep knowledge of curatorship. Prospective student should preferably have an undergraduate background in the Social Sciences and Humanities (i.e., Archaeology and Art History), but it is open to other types of background (management of cultural heritage). <i>Research Units contributing to the track</i> All IMT research units could participate in MUSST activities.
PhD in "Economics, Analytics and Decision Sciences"	The Doctoral Program in Economics, Analytics and Decision Sciences is based on the development of skills that underlie the quantitative and qualitative analysis of the phenomena observed in economic and social systems. The Program aims at providing participants with a solid knowledge of modern analytical methods, following a multidisciplinary approach. The Program develops a strong integration of concepts, analytical methods, and practical skills to train the new generation of economists, social scientists, managers, and professionals with specific competencies in the analysis, interpretation, and management of the complexity of economic, firm, and social systems. Students are trained to become researchers and decision-makers in academia, politics, administration, and business, through the integration of knowledge that lies at the borders between economics, management, and the other social sciences, while maintaining the unifying language of mathematics and statistics and borrowing the tools necessary for specific applications from computer science and psychology. The close connection with a selected group of companies and institutions offers the opportunity to adopt new perspectives of analysis and interpretation of phenomena through innovative quantitative and qualitative research methodologies for solving the problems of the real economy and society. Students are therefore involved in the collection and analysis of high-dimensional real-world data. The Program is characterized by the interdisciplinary nature of its approach. The obstacles that traditionally divide the different domains of knowledge are overcome by addressing the problems that arise in the various application fields - industrial, institutional, health, environmental, technological, social, ethical, etc. - through a variety of scientific methodologies derived from probability theory, theory of the firm, mathematical statistics, econometrics, machine learning, experimental methods, cognitive science, computer science, and computational methods. The Program is characterized by the presence of three major areas of knowledge and application that can be traced back in a broad sense to economics, management, and decision sciences. These areas are characterized by a common training in the analysis of the behavior of economic decision-makers and in the statistical-econometric analysis of data and evidence, but they can then be modulated and combined towards the individual specific needs of the candidate. Ideally, there will be three prototypical outgoing profiles: one encompassing economics and management, one encompassing management and decision sciences, and one encompassing economics and decision sciences.

PhD in "Economics, Analytics and Decision Sciences"	In particular, the Program offers training in the use of tools and methods such as statistical learning, networks analysis (physical and virtual), analysis of business dynamics, strategy evolution and dynamic capabilities, analysis of dynamic systems (stochastic and deterministic), analysis of firm performance, analysis of Environmental Social Governance (ESG), high-dimensional econometrics (characterized by significant and highly innovative computational components), experimental methods (in the field, in the laboratory and online), simulations of interactive systems made of interactive decision-makers (agent-based models). These tools allow the study of economic and social systems that are typically difficult to analyze due to the size and complexity of the mechanisms underlying their evolution and, at the same time, they make it possible to acquire and effectively analyze large datasets. These methodological skills, both quantitative and qualitative, provide students with a wide applicative versatility and a shared vocabulary to deal with a broad spectrum of phenomena typical of economic, firm, and social systems. <i>Incoming and outgoing profiles:</i> INCOMING The EADS program welcomes candidates with training in one of the following subject areas: economics, management, statistics, law, physics, computer science, engineering, logic and philosophy of science, mathematics, cognitive and behavioral sciences, or in contiguous areas. The ideal candidate is interested in acquiring distinctive competencies in economics, statistics, management, and neuroscience, but does not necessarily need to have previous training in these areas. However, the candidate must demonstrate solid quantitative skills comparable with those typically acquired in economics-managerial degrees. OUTGOING The Program prepares to face, analyze and solve a broad spectrum of complex and interdisciplinary problems of relevance at the institutional, social, and industrial levels, with the primary objective of identifying sustainable solutions and designing effective intervention policies in the economic and social spheres, as well as in business life, understood in a broad sense. Outgoing profiles share a distinctive common part of training on the behavior of economic decision-makers and the statistical-econometric analysis of data and evidence, plus dedicated specialization along the lines of economics and management, management and decision sciences, or economics and decision sciences. Job placement opportunities range from academia, in the various disciplines of the CUN 13 macro-area (economic sciences and statistics) and contiguous areas, to the public sector, international institutions, research laboratories, study centers, and regulatory authorities, as well as the private sector (services, industry and professional advice). <i>Research units collaborating with EADS</i> AXES, SysMA, DySCO, MoMiLab, Networks, LYNX
PhD in "Economics, Analytics and Decision Sciences"	Students also have the opportunity of completing their research projects under joint supervision (double-degree) with partner universities, including KU Leuven and the University of Alicante. All students are encouraged to spend periods abroad, both within the Erasmus+ framework and through ad-hoc mobility agreements, taking advantage of strong ties with selected companies and international institutions.

PhD in "Systems Science"

The Doctoral Program in Systems Science aims to provide the necessary methodological skills to analyze technological, natural, economic, and social systems by means of descriptive and predictive mathematical models. Examples of current and relevant problems in modern society that can be treated using such methodologies are ensuring the efficiency of industrial and manufactured production systems, addressing the complexity of economic, biological, ecological and social systems, and making cyber-physical systems, in which software and physical systems interact, autonomous and reliable. These issues play an essential role in many industrial sectors, such as in the automotive, aerospace, chemical, infrastructure, energy, biomedicine, financial, and manufacturing industries.

During the doctoral course, the Ph.D. student will acquire skills to develop, use, and apply methodologies for analyzing and predicting complex phenomena through analytical and computational models derived both from first principles and from data, drawing on interdisciplinary fields such as mathematics, operations research, physics, statistics, computer science, and engineering. More specifically, these skills are acquired by the student within one of the following four specialization tracks:

- *Complex Systems and Networks (CN)*
- *Computational Mechanics (CM)*
- *Learning and Control (LC)*
- *Software Quality (SQ)*

Each track offers a specialized "vertical" preparation on the corresponding reference, providing a high level of preparation, which is not normally possible to get during undergraduate studies, that is strongly requested for by both academic and non-academic jobs. At the same time, through the attendance of basic courses, candidates belonging to different tracks will be exposed to the techniques and methodologies developed in contiguous, although traditionally not very communicative, disciplinary fields, fully realizing a "horizontal" interdisciplinary training. Overall, the advanced training offered allows students to broaden their range of skills, considerably improving their ability to tackle frontier research problems within their disciplinary field successfully. The student composes his or her study plan by selecting courses from a basket of basic and advanced courses offered by the School, as well as of courses related to soft skills that are useful for the training of a researcher.

The educational offer of the Program includes several topics: machine learning for the reconstruction of models from data to stochastic processes, network analysis, analysis and control of dynamic systems, analysis of time series, numerical optimization, numerical integration of differential equations, statistics, agent-based models, specification languages, programming, and software analysis. In fact, the study of extremely complex systems in terms of size and / or dynamic richness requires mastering an increasingly refined and innovative set of computational techniques. Focusing on this core of general methodological skills provides the student with a shared vocabulary and a wide set of versatile tools to address various application problems of strong industrial and social interest.

Thesis supervisors and course lecturers are internationally recognized experts for their contributions to science and technology transfer. Ph.D. students also can also interact with other institutions and companies that the School already collaborates with.

**Track in
"Computational
Mechanics"
(CM)**

PhD in "Systems Science" Track in "Computational Mechanics" (CM)	- Applications to renewable energies (hydrogen, photovoltaics, etc.); - Quantitative methods for cultural heritage (compatibility of materials for restoration, archaeometry techniques, etc.). The activities of modeling, coding of algorithms in computational codes and simulation of systems will be further enhanced and supported by the interdisciplinary project "Scientific computing for natural and social sciences and applications: methodological and technological development" coordinated by the IMT School for Advanced Studies Lucca and in cooperation with Scuola Normale Superiore in Pisa, the International School of Advanced Studies in Trieste, the IUSS University School in Pavia and the Gran Sasso Science Institute in L'Aquila. Research can be enriched and complemented by experimental activities at the MUSAM-Lab laboratory (https://www.imtlucca.it/en/ricerca/laboratori/musam-lab) or at the laboratories of the universities and research centers of the companies with which collaborations are active. The doctoral program includes a research period abroad generally lasting no less than 6 months. <i>Input and output profiles</i> Prospective students should preferably have a background in engineering, mathematics, computer science, physics, statistics, or a related field. Potential students are free to propose a research topic of interest to them. The CM track prepares researchers and professionals capable of analyzing and proposing solutions to various real problems of industrial, economic and social interest, making them qualified to work in high-profile professional roles within universities, research centers, and the private sector. For more information regarding the activities and research personnel relating to the track, please refer to the link http://musam.imtlucca.it/
PhD in "Systems Science" Track in "Complex Systems and Networks" (CN)	Many of the challenges in modern society require the understanding and management of the complexity of physical, biological, social, economic, financial, and technological networks. Besides the traditional difficulties inherent in the study of the <i>components</i> of these systems (such as atoms, cells, individuals, organizations, devices), over the last decades, an additional (and often dominant) level of complexity has emerged, which derives from the <i>interactions</i> among the components of a system. In a world that is increasingly interconnected at the physical, social, cultural, economic, and digital levels, the bodies of knowledge developed by individual scientific disciplines are becoming less and less exhaustive, and the need for innovative interdisciplinary approaches emerges forcefully. The Theory of Complex Systems and the Science of Networks are modern approaches to the study of complex systems characterized by a large number of heterogeneous interacting components that are interconnected in irregular architectures - i.e., structures that are quite different from those traditionally considered in the natural and social sciences. Indeed, while the interactions among atoms in simple materials can be represented as regular and symmetric lattices and those among social actors or economic agents as homogeneous structures, <i>real-world</i> networks of interaction among the constituents of cells, organisms, ecosystems, societies, economies, and infrastructures turn out to be extremely heterogeneous. Examples of recurrent structures in empirical networks are the coexistence of elements (<i>vertices</i>) displaying

PhD in "Systems Science" Track in "Complex Systems and Networks" (CN)	such diverse numbers of connections that the notion of "average number of connections per node" becomes meaningless (<i>scale-free property</i>), the tendency of vertices with "neighbors in common" to be also connected among themselves (<i>clustering or triadic closure</i>), a larger cohesion within certain sets of vertices (<i>community structure</i>) and the abundance of specific substructures (<i>motifs</i>). Complex systems also exhibit collective properties that emerge from the interactions among their constituent elements that cannot be traced back uniquely to the intrinsic properties of the latter. Besides the need to characterize the complex structure of large-scale real-world systems, understanding the consequences of structural complexity for the dynamics of processes that typically take place on those systems has become more and more important. For instance, recent financial, economic, and health crises have shown how the highly irregular and inhomogeneous structure of real networks of interaction (among banks, firms, or people) deeply complicates the management (and even more so the prediction) of stress and disease propagation in modern economies and societies. Indeed, the phenomenology of these processes crucially depends on which vertices are hit first, which and how many vertices are directly connected to them, and so on - along intertwined chains of interaction. Finally, in many contexts (e.g., in ecology and economics), a strong interplay is observed between the structure of networks and the dynamics of processes taking place in it: not only network structure impacts the dynamical process, but also (and conversely) the dynamical process impacts network structure. The PhD track in <i>Complex Systems and Networks</i> offers a multidisciplinary scientific background aimed at empirical analysis, mathematical modelling, theoretical understanding and development of novel methodologies for the study of complex systems, as well as their application to problems of societal relevance. The program, among the few of its kind at the international level, places theoretical research in networks and complex systems science as its distinctive core component, emphasizing methodological innovation (such as the introduction of novel quantitative methods of analysis). The teaching program consists of doctoral courses that cover both a broad spectrum of theoretical knowledge (graph theory, random matrices, stochastic processes, statistical physics, complex networks, information theory, dynamics on networks, machine learning, optimization) and a wide range of possible applications (to financial, economic, social, biological, neural, ecological, energetic, infrastructural systems). The theoretical methods introduced in the courses include techniques of pattern detection in empirical systems, time series analysis, network inference from partial information, physical models of complex systems and networks, and noise filtering in networks and time series. The applications include problems related to financial regulation, economic resilience, sustainability, ecological stability, (mis)information diffusion, and health. Besides the institutional courses, the program offers several seminars by international researchers and experts, visiting research and training periods abroad (possibly also as co-tutelle), and constant supervision from the PhD advisor(s) and the professors contributing to the track, as well as from their international collaborators. <i>Input and output profiles</i> Candidate PhD students who wish to carry out research oriented primarily towards theoretical modelling and methodological innovation should preferably have a background in physics, mathematics, computer science, statistics, engineering, or a related field, while those who have more applied interests (to economics, biology, social
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PhD in "Systems Science" Track in "Complex Systems and Networks" (CN)	science, sustainability, etc.) should preferably have a strong quantitative background in the respective field. The PhD track trains both towards an academic career (in university departments or research centers, primarily in statistical physics, applied mathematics, and information theory) and towards the public sector (e.g., governmental institutions, statistical offices) and the private environment (data scientists, quants, analysts). For more information regarding the activities and the research personnel linked to the PhD track, please visit https://networks.imtlucca.it/
PhD in "Systems Science" Track in "Learning and Control" (LC)	The massive amount of data generated by sensors, smartphones, computers, and web platforms, inside home automation systems and intelligent devices, artifacts such as vehicles and robots, production processes, smart energy grids, and many others have made our lives increasingly data-driven. This availability of data, combined with the possibility of having increasingly powerful and pervasively distributed computing units both within the devices (embedded) or in multiprocessor boards connected to them and in the cloud, now makes new skills necessary to know how to use the data to predict the behavior of the system that generates them and to make decisions autonomously based on the information contained therein, preferably in an efficient and robust way from a computational point of view. These skills are necessary for engineering industrial automation systems and robots and in various other contexts, such as critical infrastructures (energy networks, urban mobility, water networks), self-driving vehicles, financial systems, biomedical systems, home automation, etc. The doctoral track in Learning and Control (LC) offers interdisciplinary doctoral training for graduate students who wish to specialize in the research and development of algorithms for machine learning of models starting from data and for the control of dynamic systems based on numerical optimization. These methodologies allow understanding the system's dynamics that generate the data by learning mathematical models that give the ability to analyze its behavior, predict possible future evolution scenarios, and diagnose malfunctions. Moreover, they allow improving its overall behavior using real-time control algorithms, making the system autonomous in acting optimally and safely to pursue pre-established objectives. These methodologies are independent of the physical nature of the system under study. Therefore, they apply to a myriad of real problems, such as allowing both a vehicle to drive autonomously and avoid obstacles or a satellite to change its attitude and a smart electricity grid to make the most of energy from renewable energy sources. The curriculum includes some basic courses capable of providing solid training on machine learning techniques, numerical optimization, analysis and control of dynamical systems, and computer programming. In particular: • Model predictive control • Machine learning algorithms • Numerical optimization • Reinforcement learning In addition to the basic courses, there will be specialized research seminars on frontier research topics and the possibility of attending thematic doctoral schools. The doctoral program also allows spending a research period abroad, generally lasting between 3 and 12 months. <i>Input and output profiles</i>

PhD in "Systems Science" Track in "Learning and Control" (LC)	Prospective students should preferably have training in engineering, mathematics, computer science, physics, statistics, or a related field. Potential students are offered frontier research topics or are free to propose a research topic of interest to them. The LC track prepares researchers and professionals capable of analyzing and proposing solutions to various real problems of industrial, economic, and social interest, making them qualified to work in high-profile professional roles within universities, research centers, and in the private sector, such as in the automotive, aerospace, chemical, manufacturing, infrastructure, energy, urban mobility, biomedical, and various other sectors. Professional figures able to manipulate data using mathematical algorithms are also particularly sought after in emerging sectors such as electronic commerce, social networks, finance, and many others. These Ph.D. figures are particularly appreciated for their extreme versatility, mastering methodologies for approaching the formulation and resolution of problems, and very general algorithmic and computer skills. Ph.D. students have the opportunity to collaborate with other institutions and companies with which the Research Units of the IMT School have established partnerships. For more information regarding the research activities and the researchers related to the LC track, please refer to the link http://dysco.lab.imtlucca.it
PhD in "Systems Science" Track in "Software Quality" (SQ)	The growing pervasiveness and centrality of software systems in all aspects of life requires the development of new methodologies for their analysis, design, and validation in order to meet the increasingly stringent quality criteria required for their effective operation. Quality issues have arisen, for example, in numerous events of publication of sensitive data of companies and institutions, or the public outcry following recent events of crashes of public administration platforms developed for various forms of economic support in response to the Covid emergency. The track in Software Quality (SQ) focuses on software as the main object of study around which to develop skills to improve its quality along the complete life cycle, from requirements analysis to validation and testing, considering both functional properties, i.e., program correctness, and the extra-functional ones such as usability, accessibility, reliability, performance, and security. The educational objective of the SQ track is to train researchers able to analyze, manage and anticipate software quality issues relevant to the digital transformation processes of society, including the following: digital identity, secure authentication, and data privacy; database design for interoperable cloud-based information systems; strengthening the cybersecurity perimeter of critical infrastructure; explainable artificial intelligence systems to clarify the motivations behind automated decisions; methodologies to increase energy efficiency for software; and methodologies for auditing software technologies and systems to certify their quality. The SQ track develops expertise in computer science in formal methods, programming languages, software engineering, cybersecurity, cloud computing, machine learning, and artificial intelligence. In addition, the SQ track will draw, in an interdisciplinary fashion, from adjacent fields such as control engineering (for the development of methods for optimal software self-adaptation to unanticipated external stimuli), numerical analysis (for the development of efficient techniques for analyzing performance models of software systems), operations research, and statistical physics (development of predictive models).

PhD in "Systems Science" Track in "Software Quality" (SQ)	The course program is developed consistently with the educational objective. Specifically, courses will cover aspects related to software engineering (requirements engineering, methodologies of development and audit of software projects), mathematical methods for correctness (formal methods, program verification), modeling and simulation (machine learning, stochastic processes, performance evaluation, reliability, optimization) and computer security. PhD students belonging to the SQ track will be involved in the joint training project in "Software Quality" with the PhD program in Computer Science of the Gran Sasso Science Institute (GSSI) of L'Aquila. This project stimulates the mobility of faculty and students between the two locations, the possibility of joint thesis co-supervision, and the activation of joint laboratories for the experimentation of techniques and methodologies for software quality. <i>Incoming and Outgoing Profiles</i> Applicants will preferably be graduates in computer science or related disciplines and candidates with backgrounds in the mathematical, physical, and statistical sciences with applied interests in software quality. The SQ track prepares for both further academic careers and the transfer of acquired skills to the public and private sectors. For more information regarding the track's activities and research staff, please see https://sysma.imtlucca.it/
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