UNIVERSITÀ DI PISA
Dipartimento di Informatica

Master degree programme in
Data Science and Business Informatics
(2 years, 120 ECTS)

Study plan rules ("Regolamento") and students' guide
Starting from Academic Year 2024/25

Contact for information
datascience@di.unipi.it

Web site
https://www.di.unipi.it/en/education/mds

Last update: **22 July 2024**

Preamble

The two years Master degree programme *Data Science and Business Informatics* is designed to prepare graduates both to master the information technologies and to understand the needs of organizations with a specific training in *Business Intelligence* and *Data Science* for decision support.

Most of the courses of the Data Science and Business Informatics degree are taught in English. *A small number of courses are taught in Italian, namely those marked with an asterisk in this document*. For international students, the study plan will be entirely taught in English. For Italian students, they must have a sufficient knowledge of English at enrollment time, at least at B2 level.

The master programme requires a solid background, high motivation, and hard working attitude. Concept abstraction, problem solving, formal modeling, mathematical reasoning, and basic concepts on computer programming and databases are essential characteristics that you should possess. Students shall not underestimate this advice.

The assessment of a course consists usually of a written and an oral exam. In the written exam, the student must demonstrate the use of knowledge of the course contents to solve problems. During the oral exam the student must be able to demonstrate knowledge of the course contents and be able to discuss the topics thoughtfully and with propriety of expression.

Attendance at courses is not mandatory. Part-time students, however, experience lower success rates in exams and longer time to graduate. We greatly recommend students to regularly attend lectures and to complete the courses each semester.

Our graduates are highly sought after in the job market. Not only statistics show that 100% of graduates are hired within one year from graduation, but also that they are assigned responsibility roles. This is the reward for their commitment and motivation.

Contents

Objectives and admission

1.1 Objectives of the study program

The two year graduate program in *Data Science and Business Informatics* has been designed to meet the constant demand for professionals with an interdisciplinary skills both in informatics and in business to satisfy the increasing demand by companies to compete using analytics and data science methods. The graduate program is focused on Business Intelligence and Data Science techniques to support decision making. The interdisciplinary competence covered by the Data Science and Business Informatics degree is intended to overcome the cultural divide between IT and management. In fact, as reported by several studies and publications, there is a shortage of trained professionals who can integrate the various skills and approaches necessary to overcome the traditional distrust of managers in involving computer professionals in decision-making. This is because computer professionals tend to be regarded as bearers of important but highly specialized knowledge, which may either seem difficult to apply or which has little relevance to the needs of organizations.

The professional profile of graduates in *Data Science and Business Informatics* is wider than traditional IT professionals with skills in areas such as operational information systems to support business activities. The aim is to provide graduates with specific professional skills that lead to an effective dialogue with managers to support tactical and strategic activities. To achieve this goal, key skills include *Business Intelligence* and *Data Science* (e.g. data warehousing, machine learning and artificial intelligence, data mining, business process modeling, big data analytics, visual analytics, text analytics). These technological skills are complemented by economic, statistical, and managerial skills on decision-oriented rather than just operational activities. In fact, the economic and business skills enable graduates to understand the operational performances of an organization and the decision-making criteria adopted by the management. The computer science skills enable them to translate this understanding into models using the latest IT technologies, in order to contribute significantly to an organization's decision-making and to the systematic innovation of products, processes and services. Finally, *Data Science and Business Informatics* graduates will have the skills necessary to access more advanced levels of university education, such as the PhD programs in Artificial Intelligence, Data Science, Computer Science, etc.

1.2 An inter-class program

The Italian university system classifies study programs in classes. Starting from A.Y. 2022/23, the graduate program in *Data Science and Business Informatics* is an inter-class program of LM-18 Informatics (the Computer Science class) e LM-DATA Data Science (the Data Science class).

LM-18 Informatics is the classical Computer Science class, which allows, after graduation, for taking the exam to access the Italian professional order of Computer Engineers.

LM-DATA Data Science is a new class of master programmes. It does not allow for accessing the Italian professional order of Computer Engineers. However, it allows for taking the exam for Italian high-school teaching of Mathematics or Physics (depending on the Bacherlor study program).

At enrolment time, unless explicitly chosen by the student, the degree class is LM-18 (Computer Science). Students who intend to change the class to LM-DATA, within the first year, can do so by filling in the form available here and sending it to the Students' Office (att. Mrs Rosaria Mongini).

There is only one curriculum, *indipendently from the classs students are enrolled in*, which includes an intensive study of in computer science topics, specifically data science subjects, as well as topics in mathematical optimization and statistics, and organization management. Students have a high freedom of choice in completing their curriculum. Thesis can be done as a research project or as an internship in one of the many companies that collaborate with the Department of Computer Science.

1.3 Admission requirements

Applicants must hold a first cycle degree in Computer Science (Italian class: L-31), Computer Engineering (L-8), Statistics (L-41), Economics (L-18 or L-33), Physics (L-30), Matematics (L-35) or in the same classes according to Italian Law D.M. 509/1999. Students are admitted also if they hold a Bachelor degree with at least 40 ECTS credits in the following areas: Management and Economics (SECS-P/*, ING-IND/35), Informatics (INF/01, ING-INF/05), Physics (FIS/*), Mathematics (MAT/*), Statistics (SECS-S/*). In the case of academic qualifications obtained abroad, exceptions may be made only with a resolution of the Admissions Committee, on the basis of the specific background of the candidate.

Applicants must also be fluent in English, e.g., holding a certificate at level B2 or higher of CEFR or an equivalent other certificate or holding one of the following:

- at least 6 ECTS of L-LIN/12 "Lingua e traduzione lingua Inglese";
- proficiency certificate at level B2.1 rilasciato given by CLI (Centro Linguistico) of the University of Pisa;
- IELTS with score at least 5.5;
- TOEFL iBT with score at least 72;
- First Certificate in English;
- B2 certification given by any (public or private) authorized body;
- any other studies and experiences to be assessed by an interview.

The Master degree has not a maximum quota of admitted Italian or EU students.

Extra-UE students. There are quotas on the number of extra-UE students that can enroll. Information on how to apply for the Master Programme can be found at:

www.di.unipi.it/en/education/mds/enrollment-for-foreign-students

Pre-applications will undergo a selection process. For more information, follow the link above.

1.4 Pre-requisites

Basic knowledge on discrete mathematics, logics, computer programming, algorithmics, and data bases is required. Such topics are typically part of Bachelor programs in Computer Science or in Computer Engineering. Students with other Bachelor programs, if admitted, will learn such topics through one or more of the following elective subjects based on their specific Bachelor program:

- Programming for data science (12 ECTS),
- Algorithms and data structures for data science (9 ECTS),
- Databases (6 ECTS).

Program overview

The Master programme is offered by the Department of Computer Science, and it has the following structure:

- Subjects with 48 ECTS credits from the *Informatics* area.
- Subject with 15 ECTS credits from the *Mathematics and Statistics* area.
- Subjects with 9 ECTS credits from the *Business Economics and Business Law* areas.
- Subjects with 12 ECTS credits from the *Business Economics*, *Business Law*, *Mathematics* and *Informatics* areas.
- Elective subjects with 9 ECTS credits .
- A thesis with 27 ECTS credits, which can be associated with an internship in a public institution or in a private company, both in Italy and abroad.

The effort for each subject is given in ECTS, which consists on average of:

1 ECTS = 25 hours of study = 8 hours of teaching + 17 hours of study on your own.

Courses are organized in two semesters per year. Each course is taught in a specific semester only (except for annual courses taught over two semesters).

2.1 Study program

The study program depends on the student's Bachelor degree, but in all cases it will be designed to give an interdisciplinary expertise in informatics, data science and business.

Courses marked with an asterisk are offered in Italian.

Courses from the *Informatics* area (48 ECTS)

- **Data mining** (INF/01 ECTS 12 DM 420AA)
  - Module I: Data mining: fundamentals (6 ECTS 1 Sem.)
  - Module II: Data mining: advanced topics and applications (6 ECTS 2 Sem.)
- **Business process modeling** (INF/01 ECTS 6 BPM 295AA 1 Sem.)

– **Decision support systems** (INF/01 ECTS 12 DSS 801AA)
  – Module I: Decision support databases (6 ECTS 1 Sem.)
  – Module II: Laboratory of data science (6 ECTS 1 Sem.)

– **Elective courses from GR1 group from Table 2.1 (18 ECTS)**

Course	Description				
	Area	ECTS	Abbr.	Code	Sem.
Area *Informatica*					
Advanced databases	INF/01	9	ADB	641AA	2
Advanced lab of complex network analysis	INF/01	6	ALC	0017A	1
Algorithms and data structures for data science	INF/01	9	ADS	751AA	2
Databases	INF/01	6	DB	765AA	2
Distributed data analysis and mining	INF/01	6	DDAM	687AA	1
Geospatial analytics	INF/01	6	GSA	783AA	1
Information retrieval	INF/01	6	IR	289AA	1
Machine learning	INF/01	9	ML	654AA	1
Programmatic advertising	INF/01	6	PRV	634AA	1
Social network analysis	INF/01	6	SNA	668AA	2
Technologies for web marketing	INF/01	6	TWM	537AA	2
Text analytics	INF/01	6	TXA	635AA	1
Visual analytics	INF/01	6	VA	602AA	2

Table 2.1 GR1 Group of choices.

Courses from the *Mathematics and Statistics* area (15 ECTS)

– **Optimization for data science** (MAT/09 CFU 6 ODS 784AA 1 Sem.)
– **Statistics for data science** (SECS-S/01 CFU 9 SDS 628PP 2 Sem.)

Courses from the *Business Economics and Business Law* areas (9 ECTS)

– **Elective courses from GR2 group from Table 2.2 (9 ECTS)**

Course	Description				
	Area	ECTS	Abbr.	Code	Sem.
***Business Economics* area**					
Analisi e gestione dei costi*	SECS-P/07	9	AGC	265PP	2
Financial analysis and performance measurement	SECS-P/07	6	FAP	0003P	1
Fundamentals of business management	SECS-P/07	9	FBM	627PP	1
Economia e gestione delle imprese*	SECS-P/08	9	EGI	049PP	2
Management practice	SECS-P/08	6	MP	629PP	2
Organizzazione aziendale*	SECS-P/10	9	OA	357PP	2
Pianificazione e controllo gestionale*	SECS-P/07	9	PCG	278PP	1
Project design & management for data science	ING-IND/35	6	PDM	1075I	1
Strategic and competitive intelligence	ING-IND/35	6	SCI	787II	2
***Business Law* area**					
Diritto dell'informatica*	IUS/01	6	DIR	058NN	1

Table 2.2 GR2 Group of choices.

Courses courses from the *Business Economics*, *Business Law*, *Mathematics* and *Informatics* areas (12 ECTS)

– **Elective courses from GR2 group from Table 2.2 and/or from GR3 group from Table 2.3 (12 ECTS)**

Course	Description				
	Area	ECTS	Abbr.	Code	Sem.
***Informatics* area**					
Ingegneria del software*	INF/01	6	IS	271AA	1
Programming for data science	INF/01	12	PDS	667AA	1
***Mathematics* area**					
Model-driven decision making methods	MAT/09	6	MDD	666AA	2
***Business Law* area**					
Legal issues in data science	IUS/02	6	LDS	381NN	2

Table 2.3 GR3 Group of choices.

Courses from elective subjects (9 ECTS)

– The student can choose one or two courses among the ones from groups GR1, GR2, GR3 or from GR4 group from Table 2.4 to reach 9 ECTS. Suggested courses depend on the Bachelor degree program of the student.

Course	Description			
	Area	ECTS	Code	Sem.
***Informatics* area**				
Artificial Intelligence fundamentals	INF/01	6	643AA	1
Continual learning	INF/01	6	791AA	2
ICT risk assessment	INF/01	9	303AA	1
Peer to peer systems and blockchains	INF/01	6	261AA	2
Intelligent systems for pattern recognition	INF/01	9	760AA	2

Table 2.4 GR4 Group of choices.

2.2 Precedences

There is no formal precedence between courses. However, the following order should be respected to be able to attend subjects with profit:

- for **Algorithms and data structures for data science** to have attended: **Programming for data science**;
- for **Analisi e gestione dei costi** to have attended: either **Fundamentals of business management** (if in the study plan);
- for **Decision support systems** to have attended: **Data mining**.
- for **Distributed data analysis and mining** to have attended: **Data mining**;
- for **Geospatial analytics** to have attended: **Data mining**;
- for **Information retrieval** to have attended: **Algorithms and data structures for data science** (if in the study plan);
- for **Financial analysis and performance measurement** to have attended: **Fundamentals of business management** (if in the study plan);
- for **Model-driven decision making methods** to have attended: **Optimization for data science**;
- for **Pianificazione e controllo gestionale** to have attended: **Fundamentals of business management** (if in the study plan);
- for **Statistics for data science** to have attended: **Optimization for data science**;
- for **Strategic and competitive intelligence** to have attended: **Fundamentals of business management** (if in the study plan).

This guidelines are especially relevant for students enrolled late in the first semester.

2.3 Study plan

Student are required to submit the study plan within one month from enrollment. The study plan may be updated annually from 1st September to 31st January.

Forms for submitting the study plan and draft study plans specifically tailored to a few Bachelor degrees are available at:

https://didattica.di.unipi.it/en/master-programme-in-data-science-and-business-informatics/study-plans/

Teaching and service organization

The website of Master degree programme contains the updated information on the overall organization as well as news and announcements:

https://www.di.unipi.it/en/education/mds

Some information related to course and services offered by the Department of Economics and Management are described at the website:

https://www.ec.unipi.it/didattica/

3.1 Teachings

Academic calendar, timetable, and rooms

The academic calendar is organized over two semesters (September-December and February-May), including each at least 12 weeks of teachings. The courses from Table 3.1 may have a slightly different organization from the others, because they are offered by the study programmes of the Department of Economics and Management.

Course
***Business Economics* area**
Analisi e gestione dei costi*
Economia e gestione delle imprese*
Organizzazione aziendale*
Pianificazione e controllo gestionale*
***Business Law* area**
Diritto dell'informatica*

Table 3.1 Courses offered by the Department of Economics and Management.

Timetable of courses is published on the website before the beginning of the semester. Teaching rooms are located as follows:

– for the courses from Table 3.1 at the Department of Economics and Management, via C. Ridolfi 10, Pisa;

– for all other courses, at Polo Didattico L. Fibonacci, Largo B. Pontecorvo 3, Edificio B, Pisa.

Please, notice that the time slots for the courses from Table 3.1 (8:45-10:15,10:30-12:00,12:15-14:00,14:15-15:45,16:00-17:30-17:45-19:15) are different from all the other courses (9-11, 11-13, 14-16, 16-18).

Attendance

No course requires mandatory attendance.

Course program and teaching material

The VALUTAMI web portal provides a list and several information on courses:

esami.unipi.it

For each course, there is a description of the learning objectives and course program. Moreover, there is a link to the course web page, maintained by the teacher of the course, with additional information, such as: calendar of lessons, slides, teaching material, exercises, audio-video recordings, etc.
The official final program of a course is available at the website unimap.unipi.it, by searching for the surname of the teacher, then the link "Attività didattica" and then the link "Registro delle lezioni".

Exams and mid-terms

Exams consist typically of a written test and/or a project and an oral test. Sometimes, the written test cam be passed during the semester through mid-term tests, typically one at the mid of the semester and one at the end of the semester. The academic calendar states the periods when mid-terms can take place. The grades for passing an exam are on a scale from 18 to 30 cum laude. The given grade can be declined by the student: in such a case, the exam must be repeated from scratch. The enrollment to an exam session ("appello") must be done on the VALUTAMI web portal esami.unipi.it. For a few categories of students, there are two additional exam sessions ("appelli straordinari"), scheduled around the mid of each semester. Such categories are: students enrolled from third year on ("fuori corso"), parents with children below eight year old, pregnant students. See the following link for the procedure to apply for the additional exam sessions: https://didattica.di.unipi.it/en/appelli-straordinari/.

Student questionnaire

In the last weeks of each semester, students must fill a questionnaire for each course attended during the semester (for courses over the whole academic year, this is required only in the second semester). Questionnaire can be filled on the web portal VALUTAMI esami.unipi.it.

When enrolling to an exam session, the system will check if the questionnaire has been filled. If not, before enrolling, the student will be forced to fill the questionnaire.

The answers are anonymized and no link is left between the student and the answers. The questionnaire is extremely relevant to understand the feelings of the students about the course contents, materials, and teacher(s). They will be thoroughly considered for taking actions to improve the course in the following years.

3.2 International mobility: Erasmus+ and double degree

Students can apply for the Erasmus+ programme for a period (one semester, one year) in a European university both for taking exams or for doing the thesis. Incoming Erasmus+ students also regularly come to Pisa to attend the courses of the Master degree programme in Data Science and Business Informatics.

A double degree program consists of a study program designed by two Universities. The graduated student will have two titles of study, given by each of the Universities. Students can enroll to a double degree program with the University of Paris-Dauphine (France), offering the *Master in Informatique des Organisations (parcours Informatique pour la Dècision de la 1ère annèe de Master et parcours MIAGE Informatique Dècisionnelle de la 2ème annèe de Master)*. There is a quota of five students per year admitted to the double degree program.

For more information: https://didattica.di.unipi.it/en/master-programme-in-data-science-and-business-informatics/studying-abroad-msc-in-data-science/.

3.3 Service organization

Office hours and tutoring

Contacts, office addresses and office hours (weekly or on appointment) of teachers are available at the website unimap.unipi.it or directly at the web pages of courses. Students are strongly suggested to take advantage of office hours for clarifying any doubt about the topics of a course and the contents of each class, or for any other inquiry about a course.

By the first semester of each year, each newly enrolled student is assigned a tutor teacher, who can be contacted for general inquires about teaching. The assigned tutor is published on the web site, and the tutor remains the same for the following years.

In the first semester, there also will be an au-pair tutoring service, in which students of the second year provide information and guidance to newly enrolled students.

Computer labs, Wi-Fi and software licences

The computer labs at the Polo Didattico L. Fibonacci can be accessed outside of the schedule classes. For logging in to computers or for connecting to the Wi/Fi (name “Unipi”), students can use the credentials of Alice. Computer and information services of the labs are managed by “Polo Informatico 2 del SID” (an IT Department

of the University of Pisa), whose home page is: www.sid.unipi.it/polo2. Several agreement allows for obtaining an academic licence of software and cloud services (click on the name to be redirected):

- Microsoft Office 365
- Azure dev tools (OS, Visual Studio, SQL Server, etc.)
- MathWorks MatLab
- IBM on the hub
- Google GSuite (to active it click here).

Student secretariats and Alice portal

The student secretariat is located at Largo B. Pontecorvo 3, Edificio E. It is the primary reference for enrolling (through the International Office), for taxes, for obtaining formal certificates, for applying for graduation. Most of such services can be done online on the student web portal Alice: www.studenti.unipi.it.

Important: Alice is not synchronized with the study plan approved (which is the sole official). Some passed exams may appear as "extra" ('sovrannumerario" in Italian, *sovrannumerario*). If you need to remove the "extra" label (e.g., because you are requested so by the DSU, the office for scholarships), please send an email to

scienze.segreteriastudenti@unipi.it, with datascience@di.unipi.it in cc

and attaching the approved study plan.

The didactic unit of the Master Programme is located at Dipartimento di Informatica, Largo B. Pontecorvo 3, Edificio C, II piano. It is the primary reference for the admin papers for doing an internship, and for applying for graduation (you have to apply both online and at the didactic unit).

Centro Linguistico Interdipartimentale

The Centro Linguistico Interdipartimentale (CLI) offers language courses, including course of Italian for foreigner students.

Students with disabilities

Students with disabilities can be supported in several ways. Please contact USID - Ufficio Servizi per l'Integrazione di studenti con Disabilità. The USID offices offer technical and IT aids, tutoring, and other support facilities.

Students with Specific Learning Disorders can contact the sportello DSA, which offers assistance, tutoring, and support to them.

The Servizio di Ascolto e Consulenza per Studenti Universitari aims at supporting any student who need psychological assistance while studying at the University of Pisa.

Questionnaire for the evaluation of services and organization

Students shall fill once a year a questionnaire about the quality of services and organization. The questionnaire is available at the VALUTAMI portal esami.unipi.it. The VALUTAMI portal will prompt for filling the questionnaire (if not already filled) when registering to an exam session.

3.4 Internship project and graduation

Internship project ("Progetto formativo")

An internship project ("Progetto formativo" in Italian) consists of an agreement among the Department of Computer Science of the University of Pisa, a student preparing for doing the thesis, and a company or public institution that is willing to host the student for some period and with shared objectives. Students become part of a project team in a company project focusing on topics of Data Science and Business Informatics that have the potential to provide enough material for a Master thesis document. The internship can be done in Italy or abroad, in private companies or in public institutions. The student is supervised by a company tutor and by an academic tutor, who will act as the thesis supervisor as well.

See https://didattica.di.unipi.it/en/master-programme-in-data-science-and-business-informatics/internship/ for the ruling of the internship, for the list of companies with an agreement, and for the list of available positions.

Graduation ("Laurea")

Deadlines for graduation and instructions for applying are available at the web site of the Master programme. See https://didattica.di.unipi.it/en/master-programme-in-data-science-and-business-informatics/graduation-2/.

Relation to labour market

The current phase of digital transformation has triggered a process of innovation in organizations that builds on investing in new technologies, in their integration with the business processes, and in the constant increase of data available for analyses. This transformation is changing profoundly the information and communication technology (ICT) skills required by public institutions and private companies. Such skills will be more and more oriented towards multidisciplinarity, analytics, and process and sectorial skills (Assintel Report 2021 "ICT and Digital Market in Italy"). The recent reports "The Future of Jobs" published by the World Economic Forum, based on a global survey in the many production sectors, systematically identify "big data" and related technologies as one of the disruptive factors of change, and in the "data scientist/data analyst" one of professional figures that emerge as critical and indispensable in many sectors. The demand for professionals capable of reading and managing data, of solving advanced problems with an analytical approach, of exploiting innovation itself to improve the quality of the business, is estimated to grow more and more in the following years.

The authoritative American research company Gartner, in its periodic reports on Analytics and Business Intelligence platforms, claims that the market for Business Intelligence and Analytics platforms will remain one of the fastest growing software segments. Its growth is guaranteed by the process of digital transformation underway, from the increase in investments in analytics by companies and by the increase in the availability of data. The Gartner reports confirm the trend, already identified in the past, (see: T. H. Davenport and G. C. Harris, *Competing on Analytics: The New Science of Winning*, Harvard Business School Press, Boston 2007, and T. H. Davenport, G. C. Harris and R. Morison, *Analytics at Work*, Harvard Business School Press, Boston 2010) on the ability and willingness of modern companies to collect big data and to invest in strategies based on the analysis of such data with the Business Intelligence tools. In a famous article on Harvard Business Review, T. H. Davenport defined the data scientist "the Sexiest Job of the 21st Century".

The latest analyses of the Italian context by the Big Data and Business Analytics Observatory of the School of Management of the Polytechnic of Milan show that, despite the slowdown due to the pandemic, 96% of large companies continue to perform activities to improve the collection and valorisation of data and 42% have taken action, in terms of projects and skills, in the Advanced Analytics field. Organizations understand well that Business Intelligence tools and methods allow to create applications that help managers better understand their business and discover new possibilities for intervention to compete in today's world. As pointed out by the Ob-

servatory itself in a 2007 study (*Business Intelligence: a look at the future*), and in the literature (see e.g., the book by T. Burelli, A. Marzona, M. Pighin, *From intuition to knowledge*, Aracne, Rome, 2007), to make the most of the potential of decision support systems, companies must invest not only in technology, but also on graduates with specialized skills in computer science, economics, business management, data mining and in optimization methods. The *Data Science and Business Informatics* degree program bases its educational offering on the objective of transmitting to its own students exactly these skills, in line with expectations of the labour market.

The *Data Science and Business Informatics* programme promotes and encourages master's theses developed in collaboration with private companies and public institutions, thus favoring the rapid employability of graduates. From the results of occupational surveys of graduates conducted as part of the initiative STELLA (until 2014) and by AlmaLaurea (since 2015), it turns out that the employment rate of graduates in *Data Science and Business Informatics* is among the highest of the University of Pisa master programmes.

Relation to research activity

The Master degree programme is run by the *Department of Computer Science* of the University of Pisa. The Department of Computer Science employs 23 full professors, 26 associate professors, 31 researchers. They cover the scientific disciplinary sectors of Computer Science, Operational Research, Numerical Analysis, and Business Management. The Department of Computer Science also runs a PhD in Computer Science, offered in collaboration with the University of Florence and the University of Siena, and the National PhD programme in Artificial Intelligence and Society, jointly between the University of Pisa and CNR, Scuola Superiore Sant'Anna, Scuola Normale Superiore, IMT Lucca School, and several other universities.

The *Data Science and Business Informatics* programme also benefits from the contribution of teachers:

- of the *Department of Economics and Management*, in particular for the sharing of some courses in the Business Management sector;
- of the *National Research Council*, in particular of the *Institute of Science and Technology of Information* of Pisa;
- of the *Department of Energy Engineering, Systems, Territory and Construction*, for courses of the sector of Managerial Engineering;
- of the *Department of Law*, for courses of the sector of Private Law;
- of the *Scuola Superiore S. Anna*, for courses of the sectors of Comparative Private Law and of Economics and Business Management.

The teachers of the Master programme are engaged in research activities that are coherent, relevant and useful with respect to the objectives of the courses they taught. In particular, the following research areas are covered:

- Operational information systems: theories, techniques, languages, architectures and systems for databases and XML.
- Management information systems: theories, techniques, data science languages, data architectures and systems, business intelligence, data warehousing, data mining, big data, text mining.
- Machine learning and artificial intelligence: theories, algorithms and applications of machine learning (deep learning, reinforcement learning, learning for structured/complex data, patterns recognition, natural language processing), ethical issues in artificial intelligence.

– Business processes and services on the web: theories, techniques, languages, architectures and systems for business processes, planning and coordination of inter-company services.
– Models and methods for decisions in logistics systems: mathematical models and algorithms for production problems, transportation and distribution.
– Economics and management: economic theorys of demand, economic equilibrium, international economics, planning and control, competitive intelligence.

The multidisciplinary nature of the teachers with a mix of cutting-edge cultural, scientific and technological skills allows for guiding students along training paths to highly qualified professionals that are highly sought after in labour market.

Courses in English

This appendix reports the syllabus of the courses offered in English. Details on each course are available at the Course Catalogue:

https://unipi.coursecatalogue.cineca.it/corsi/2024/11357/insegnamenti/52766

and the web page of the course.

A.1 Compulsory subjects

Business process modeling (295AA) (6 ECTS)
Semester: 1
Contact Person: Prof. Roberto BRUNI (roberto.bruni@unipi.it)
Web Page: didawiki.di.unipi.it/doku.php/magistraleinformaticaeconomia/mpb/

Objectives
The course presents techniques for Business Analytics according to the process-driven view of Business Process Modeling. It presents the main concepts and problematic issues related to the process management, where processes are understood as workflow over some basic activities, and to show some of the languages, conceptual models and tools that can help to handle the main problems in a proper way. During the course, the students will become acquainted with the technical terminology of the area, with several rigorous models that can be used to structure and compose processes, with the logical properties that such processes can be required to satisfy and with specific analysis and verification techniques. Moreover they will be given the possibility to experiment with some advanced tools for the design and analysis of business processes.

Syllabus
– Introduction to Key Issues in Business Process Management.
– Terminology and Classification.
– Process Modeling. Conceptual Models and Levels of Abstraction.
– Rigorous Workflow Models: Petri Nets and Workflow Nets.
– Tool-supported Workflow Design and Analysis: Experimentation with Integrated Tools for Business Process Design, Analysis and Verification.

Data mining (420AA) (12 ECTS)
Semester: 1, 2
Contact Person (1st sem.): Prof. Dino PEDRESCHI (dino.pedreschi@unipi.it)
Contact Person (2nd sem.): Prof. Riccardo GUIDOTTI (riccardo.guidotti@unipi.it)
Web Page: didawiki.di.unipi.it/doku.php/dm/

Objectives
Recent tremendous technical advances in processing power, storage capacity, and interconnectivity are creating unprecedented quantities of digital data. Data mining, the science of extracting useful knowledge from such huge data repositories, has emerged as an interdisciplinary field in computer science. Data mining techniques have been widely applied to problems in industry, science, engineering and government, and it is believed that data mining will have profound impact on our society. The course is divided into two modules. The first presents an introduction to the basic concepts of data mining and the knowledge discovery process, and associated analytical models and algorithms. The second module provides an account of advanced techniques for analysis and mining of novel forms of data, and the main application areas and prototypical case studies.

Syllabus
Module 1: Foundations
– Concepts of Data Mining and the Knowledge Discovery Process.
– Data Preprocessing and Exploratory Data Analysis.
– Frequent Patterns and Associations Rules.
– Classification: Decision Trees and Bayesian Methods.
– Cluster Analysis: Partition-based, Hierarchical and Density-based Custering.
– Experiments with Data Mining Toolkits.
Module 2: Advanced topics and applications
– Mining Time-Series and Spatio-Temporal Data.
– Mining Sequential Data, Mining Large Graphs and Networks.
– Advanced Association, Correlation and Frequent Pattern Analysis.
– Advanced Classification, Cluster Analysis and Outlier Detection.
– Data Mining Languages, Standards and System Architectures.
– Ethical aspects of data mining.
– Privacy-Preserving Data Mining.
– Applications: Retail Industry, Marketing, CRM, Telecommunication Industry, Financial Data Analysis, Risk Analysis, Fraud Detection, Mobility and Transportation, Public Administration and Health.

Decision support systems (801AA) (12 ECTS)
Semester: 1
Contact Person (Module I): Prof. Salvatore RUGGIERI (salvatore.ruggieri@unipi.it)
Contact Person (Module II): Prof. Anna MONREALE (anna.monreale@unipi.it)
Web Page: didawiki.di.unipi.it/doku.php/mds/dss/start

Objectives
The course presents the main methodological and technological approaches to the design and implementation of decision support systems based on business intelligence (datawarehousing, data mining, data science). The first module covers themes such as conceptual and logical Data Warehouses design, data analysis using analytic SQL, algorithms for selecting materialized views, data warehouse systems technology (indexes, star query optimization, physical design, query rewrite methods to use materialized views). The second module presents technologies and systems for data access, for building and analyzing data warehouses, for reporting, and for knowledge discovery in databases. The accent of the module is on the use of tools and on the analysis of application problems by means of non-trivial samples and case studies.

Syllabus
Module I: Decision support databases
– Information systems and computer-based information systems in organizations.
– Decision Support System Based on Data Warehouses.
– Data Models for Data Warehouses and On-line Analytical Processing.
– Conceptual and logical design in Data Warehouses.
– Algorithms for Selecting Materialized Views.
– Data Warehouse Systems Technology: Indexes, Star Query Optimization,
– Physical Design, Query Rewrite Methods to Use Materialized Views.
– Case studies.
Module II: Laboratory of Data Science
– Introduction: Tools for data science and Business Intelligence.
– Data Access. Location, Format and API for Accessing Data in Text Files. Standards for Data Connectivity.
– Extract Transform and Load. Tool for ETL. Case studies.
– Data Warehousing and OLAP. Tools for Dimensional Modeling. Case Studies.
– Tools for Reporting and Multidimensional Browsing. Case Studies
– Data Mining. Tools for Knowledge Discovery. Case Studies.

Optimization for data science (784AA) (6 ECTS)
Semester: 1
Contact Person: Prof. Antonio FRANGIONI (antonio.frangioni@unipi.it)
Web Page: elearning.di.unipi.it/course/view.php?id=301

Objectives
The course aims at familiarising the students with the mathematical optimization methodologies underpinning many Data Science approaches, as well as with their use in combination with Data Science techniques to address relevant practical problems. The course will therefore carefully balance the methodological aspect, i.e., the theory of constrained and unconstrained optimization and of the corresponding solution algorithms, and the applicative aspect, i.e., the use of these methodologies to address Data Science issues.

Syllabus
– Basics of optimization and modelling techniques.
– Unconstrained optimization: theory and algorithms.
– Constrained optimization: theory and algorithms.
– Applications to data science and business informatics.

Statistics for data science (628PP) (9 ECTS)
Semester: 2
Contact Person: Prof. Salvatore RUGGIERI (salvatore.ruggieri@unipi.it)
Web Page: didawiki.di.unipi.it/doku.php/mds/sds/

Objectives
The course presents the main concepts and techniques of probability, statistics, and time series, which can be useful for the data analysis and data science. After consolidating the knowledge in probability theory, the course is aimed at presenting the main methods and concepts of estimation theory and hypothesis testing. The second part of the course focuses on statistical inference and validation of core data processing tasks and machine learning models. Advanced topics will cover stochastic processes and time series, focusing on the ARMA framework and Markov chains. The theoretical notions are interleaved with exercises and project work using the R programming language.

Syllabus
– Brief review on probability theory, random variables and convergence theorems for sequences of random variables.
– Exploratory data analysis: graphical and numerical summaries.
– Basic statistical models.
– The bootstrap method.
– Estimation: unbiased estimators, efficiency and mean squared error, maximum likelihood, expectation maximization.
– Least squares estimation and regression.
– Confidence intervals and hypotheses testing.
– Sampling and imputation methods.
– Categorical data and inference for contingency tables.
– Classifier error rate estimation and calibration.
– Noise and robust statistics.
– Bayesian inference.
– Causal inference: structured causal model, potential outcome model.
– Brief introduction to stochastic processes and linear time series analysis.
– Markov Chains and Monte Carlo Markov Chain.

A.2 Elective subjects from the GR1 group

Advanced databases (641AA) (9 ECTS)
Semester: 2
Contact Person: Prof. Giorgio GHELLI (giorgio.ghelli@unipi.it)
Web Page: pages.di.unipi.it/ghelli/

Objectives
The course provides advanced technical knowledge of the main issues related to the implementation and performance optimization of both classical centralized relational database systems for operational and OLAP processing and of recent advances in non-relational data models (columnar, document, key-value, graph) and scalable distributed architectures.

Syllabus
– Internals of relational database management systems.
– Optimizations of Data Warehousing management systems and On-Line Analytical Processing.
– Extract-Transform-Load and query/reporting in OLAP systems.
– Beyond SQL: NoSQL data management systems for big data.
– Distributed data processing and the Map-Reduce paradigm.

Algorithms and data structures for data science (751AA) (9 ECTS)
Semester: 2
Contact Person: Prof. Rossano VENTURINI (rossano.venturini@unipi.it)
Web Page: pages.di.unipi.it/rossano/courses/

Objectives
The course introduces basic data structures and algorithmic techniques that allow students to solve computational problems on the most important data types, such as sequences, sets, trees, and graphs. The lectures will be complemented by an intensive activity in laboratory. Students will experiment with algorithms and data structures by writing their own implementations or by using third-party libraries. The goal of the class is to enable students to design and implement efficient algorithms, choosing the most appropriate solutions in their future projects.

Syllabus
– Introduction and basic definitions: algorithm, problem, instance.
– Computational complexity analysis of algorithms.
– Sorting: Mergesort, Quicksort and Heapsort.
– Searching: Binary Search, Binary Search Tree, Trie, and Hashing.
– Algorithms on Trees: representation and traversals.
– Algorithms on Graphs: representation, traversals, and most important problems.
– External memory model: sorting and searching.

Databases (765AA) (6 ECTS)
Semester: 2
Contact Person: Prof. Giorgio GHELLI (giorgio.ghelli@unipi.it)
Web Page: pages.di.unipi.it/ghelli/

Objectives
The management of information is the main use of computers in organizations of all types and sizes.Information management is mostly based on data base technology. The aim of the course is to present the features of thesesystems, in particular the relational ones, their architecture and the principles they are inspired by, from the point of view ofapplication designers.

Syllabus
– Data base and database management system: definition and functionalities.
– Database design: conceptual modeling using the object-oriented data model.
– The relational data model.
– Mapping of conceptual schemas onto relational logical schema.
– The SQL language, with a special emphasis on the query sublanguage and its relationship with first order logic.
– Theory of relational database normalization.
– Database implementation: access plans and transaction management.
– NoSQL systems.

Distributed data analysis and mining (687AA) (6 ECTS)
Semester: 1
Contact Person: Prof. Roberto TRASARTI (roberto.trasarti@isti.cnr.it)
Web Page: didawiki.di.unipi.it/doku.php/mds/ddam/

Objectives
Mining with big data or big data mining has become an active research area. Running current analytical methodologies and software tools on a single personal computer cannot efficiently deal with very large datasets. Distributed computing platforms are a scalable solution for big data mining, obtained by dividing a large problem into smaller ones that are concurrently solved by many single processor/machine. This course aims at teaching the basic theoretical concepts behind the MapReduce distributed computing paradigm, and Hadoop in particular, and at building expertise in the practical usage of high performance computing tools for data engineering, analysis and mining. In particular the students will learn how the classical data mining algorithms can be applied on Big Data using Hadoop (Spark). Real (and open source) datasets will be used to present examples and to let the students build their own projects. Half of the lessons will consists of practice (Lab), and half of lectures.

Syllabus
– Motivations: Distributed Data Mining in a Big Data Scenario
– Recall parallel and distributed computing notions
– Introduction to Hadoop
– Hadoop Ecosystem
– Interacting with HDFS (LAB)
– Map-Reduce Programming Patterns
– Recall Python programming (LAB)
– Basic Spark (LAB)
– Data Analysis with Spark (LAB)
– Data Mining and Machine Learning with Spark (LAB)
– SparkSQL (LAB)
– Example on how to prepare a project
– Real Case Studies

Geospatial analytics (783AA) (6 ECTS)
Semester: 1
Contact Person: Prof. Luca PAPPALARDO (luca.pappalardo@isti.cnr.it)
Web Page: didawiki.di.unipi.it/doku.php/geospatialanalytics/gsa/

Objectives
The analysis of geographic information, such as those describing human movements, is crucial due to its impact on several aspects of our society, such as disease spreading (e.g., the COVID-19 pandemic), urban planning, well-being, pollution, and more. This course will teach the fundamental concepts and techniques underlying the analysis of geographic and mobility data, presenting data sources (e.g., mobile phone records, GPS traces, geotagged social media posts), data preprocessing techniques, statistical patterns, predicting and generative algorithms, and real-world applications (e.g., diffusion of epidemics, traffic simulation, urban dynamics). The course will also provide a practical perspective through the use of advanced geoanalytics Python libraries.

Syllabus
– Spatial Reference Systems
– Data formats
– Trajectory and Flows
– Spatial Tessellations
– Open-source tools for geospatial analysis
– Digital spatial and mobility data
– Preprocessing mobility data
– Individual and collective mobility laws
– Next-location prediction
– Flow generation
– Applications

Information retrieval (289AA) (6 ECTS)
Semester: 1
Contact Person: Prof. Rossano VENTURINI (rossano.venturini@unipi.it)
Web Page: pages.di.unipi.it/rossano/courses/

Objectives
Study, design and analysis of IR systems which are efficient and effective to process, mine, search, cluster and classify documents, coming from textual as well as any unstructured domain. In the lectures, we will:

– study and analyze the main components of a modern search engine: Crawler, Parser, Compressor, Indexer, Query resolver, Query and Document annotator, Results Ranker;
– dig into some basic algorithmic techniques which are now ubiquitous in any IR application for data compression, indexing and sketching;
– describe few other IR tools which are used either as a component of a search engine or as independent tools and build up the previous algorithmic techniques, such as: Classification, Clustering, Recommendation, Random Sampling, Locality Sensitive Hashing.

Syllabus
– Search engines.
– Crawling, Text analysis, Indexing, Ranking.
– Storage of Web pages and (hyper-)link graph.
– Results processing and visualization.
– Other data types: XML, textual DBs.
– Data processing for IR tools.
– Data streaming.
– Data sketching.
– Data compression.
– Data clustering (sketch).

Machine learning (654AA) (9 ECTS)
Semester: 1
Contact Person: Prof. Alessio MICHELI (micheli@di.unipi.it)
Web Page: elearning.di.unipi.it/course/view.php?id=524

Objectives
We introduce the principles and the critical analysis of the main paradigms for learning from data and their applications. The course provides the Machine Learning basis for both the aims of building new adaptive Intelligent Systems and powerful predictive models for intelligent data analysis.

Syllabus
- Computational learning tasks for predictions, learning as function approximation, generalization concept.
- Linear models and Nearest-Neighbors (learning algorithms and properties, regularization).
- Neural Networks (MLP and deep models, SOM).
- Probabilistic graphical models.
- Principles of learning processes: elements of statistical learning theory, model validation.
- Support Vector Machines and kernel-based models.
- Introduction to applications and advanced models.
- Application project: implementation and use of ML/NN models with emphasis to the rigorous application of validation techniques.

Programmatic advertising (634AA) (6 ECTS)
Semester 1
Contact Person Prof. Nicola CIARAMELLA (ciaramella@noesis-research.com)
Web Page: didawiki.di.unipi.it/doku.php/mds/pa/

Objectives
The course aims at providing students with a conceptual framework and a toolbox for optimization of online advertising campaigns (inside sites, apps, games). At the end of the course the student should be able to design and possibly implement real-life systems for optimization of campaigns performance, intended in financial and marketing terms. The required mathematical background is limited to basic differential calculus and probability theory. The treatment is quantitative and concepts will be translated in formulas and algorithms. Nevertheless, focus will be on intuition and business meaning more than on formal rigor.

Syllabus
– The online advertising ecosystem. Advertisers, publishers, business intermediaries, technology providers, data providers. Trends and Programmatic Advertising.
– Online advertising campaign management: design, targeting, creation, monitoring, optimization and reporting.
– Data about people and their behavior. Classical segmentation, micro-segmentation, one-to-one relationships. Data management platforms.
– The publisher problem. Basic micro-economic concepts and decision theory: expected utility, marginal utility, pricing, decision trees, value of information, risk and uncertainty, opportunity cost, equilibrium and optimality.
– The advertiser problem. Market segmentation, customer profiling. The advertisers-publishers game.
– Forecasting visitors and campaigns behavior. Classical methods: linear regression, logistic regression, time series analysis. Factorization methods. Markovian methods.
– Learning and optimization. Facing uncertainty. The Exp-Exp dilemma. Multi-armed bandits. Reinforcement learning.

Social network analysis (668AA) (6 ECTS)
Semester: 2
Contact Person: Prof. Dino PEDRESCHI (pedre@di.unipi.it)
Web Page: elearning.di.unipi.it/course/view.php?id=977

Objectives
Over the past decade there has been a growing public fascination with the complex "connectedness" of modern society. This connectedness is found in many contexts: in the rapid growth of the Internet and the Web, in the ease with which global communication now takes place, and in the ability of news and information as well as epidemics and financial crises to spread around the world with surprising speed and intensity. These are phenomena that involve networks and the aggregate behavior of groups of people; they are based on the links that connect us and the ways in which each of our decisions can have subtle consequences for the outcomes of everyone else. This short course is an introduction to the analysis of complex networks, with a special focus on social networks and the Web - its structure and function, and how it can be exploited to search for information. Drawing on ideas from computing and information science, applied mathematics, economics and sociology, the course describes the emerging field of study that is growing at the interface of all these areas, addressing fundamental questions about how the social, economic, and technological worlds are connected.

Syllabus
Graph theory and social networks
– Graphs.
– Social, information, biological and technological networks.
– Strong and weak ties.
– Networks in their surrounding context.
The World Wide Web
– The structure of the Web.
– Link analysis and Web search.
– Web mining and sponsored search markets.
Network dynamics
– Information cascades.
– Power laws and rich-get-richer phenomena.
– The small-world phenomenon.
– Epidemics.

Technologies for web marketing (537AA) (6 ECTS)
Semester: 2
Contact Person: TBA

Objectives
Web analytics is the collection, measurement, analysis and reporting of Internet data (web, mobile, social media, email) for purposes of deep customer and market understanding and for digital service optimization. The course presents web analytics methods, algorithms, strategies and tools with applications to web personalization for improving user experience, to web marketing and advertising for improving visibility, to search engine optimization for improving ranking, and social media analysis for improving reachability and understanding opinions. Students are required to know basic data mining and data warehousing concepts.

Syllabus
– The mobile web.
– Tools: Google analytics.
– Web personalization and user segmentation.
– Recommender systems: collaborative filtering, content based, hybrid.
– Controlled experiments on the web.
– Search engine optimization and marketing.
– Social media analysis.
– Social media scoring and marketing.
– Real time analytics.
– Privacy, profiling and regulations.

Text analytics (635AA) (6 ECTS)
Semester: 1
Contact Person: Prof. Laura POLLACCI (laura.pollacci@unipi.it)
Web Page: didawiki.di.unipi.it/doku.php/mds/txa/

Objectives
The course targets text analytics systems and applications to respond to business problems by discovering and presenting knowledge that is otherwise locked in textual form. The objective is to learn to recognize situations in which text analytics techniques can solve information processing needs, to identify the analytic task/process that best models the business problem, to select the most appropriate resources methods and tools, to collect text data and apply such methods to them. Several applications context will be presented: information extraction, sentiment analysis (what is the nature of commentary on an issue), spam and fake posts detection, quantification problems, summarization, etc.

Syllabus
– Disciplinary background: Natural Language Processing, Information Retrieval and Machine Learning.
– Mathematical background: Probability, Statistics and Algebra.
– Linguistic essentials: words, lemmas, morphology, PoS, syntax.
– Basic text processing: regular expression, tokenisation.
– Data gathering: twitter API, scraping.
– Basic modelling: collocations, language models.
– Libraries and tools: NLTK, Keras.
– Applications:
  Classification/Clustering
  Sentiment Analysis/Opinion Mining
  Information Extraction/Relation Extraction
  Entity Linking
  Spam Detection: mail spam & phishing, blog spam, review spam.

Visual analytics (602AA) (6 ECTS)
Semester: 2
Contact Person: Prof. Salvatore RINZIVILLO (rinzivillo@isti.cnr.it)
Web Page: didawiki.di.unipi.it/doku.php/magistraleinformaticaeconomia/va/

Objectives
The availability of large data sources provides new opportunities for understanding patterns and behaviors of modern society. The information from these sources requires effective visualization methods to extract meaningful information from the data and facilitate the interpretation of very complex phenomena. The objective of the course is to present an overview of basic methods and visualization techniques for effective presentation of information from different sources: structured data (relational hierarchies, trees), relational data (social networks), temporal data, spatial data and data space-time. We will present and discuss several case study scenarios with the existing methods and tools.

Syllabus
Visual Metaphors for Information
– Hierarchical and structured data.
– Relational and graph-based data.
– Temporal Data.
– Spatial data.
– Spatio-temporal data.
– Unstructured information (text).
Methods and Tools
– Overview of existing visual analytics environments.
Visual Analytics Process
– Definition of a Knowledge Discovery process.
– Framework for VA.
– Visual exploration and analytics of data.
– Case studies.

A.3 Elective subjects from the GR2 group

Fundamentals of business management (627PP) (9 ECTS)
Semester: 1
Contact Person: Prof. Mariarita PIEROTTI (mariarita.pierotti@unipi.it)
Web Page: elearning.di.unipi.it/course/view.php?id=321

Objectives
The course is designed to introduce students from different backgrounds (especially from STEM disciplines) to the most relevant topics and concepts characterizing business management, and to provide them with the ability to apply business management knowledge to practical tasks. The topics proposed are relevant to a variety of application sectors, and cover both theoretical concepts and relevant managerial implications. The course will also introduce students to the basic concepts of financial and managerial accounting, including concepts of costs, volumes and profits, and their relationships, budgeting, performance measurement and evaluation. Students will increase their familiarity with the accounting process, and will learn to read and understand financial statements. The course will also discuss the economics and management of strategic decisions and human capital.

Syllabus
– The firm and the market
– What is a firm?
– Theories of the firm
– The firm as a sustainable system
– Where does a firm work, interact and evolve?
– Value creation and firm's objectives
– The competitive advantage and the entry strategies
– The firm's functions
– Production, Research & Development, Accounting, Finance, Innovation
– Processes and techniques of marketing
– Operations management
– Procurement and logistics
– Finance
– Principles of financial accounting and budget
– Firm's value, finance and capital structure
– Resources management, strategy, business models
– Economics and management of strategic decisions
– Governance, networking and strategic collaboration
– Human resources management practices

Notice: this course and *Economia Aziendale II* cannot be both present in the study plan. Moreover, this course cannot be chosen if the student bachelor is from the *Economics* area.

Management practice (629PP) (6 ECTS)
Semester: 2
Contact Person: Prof. Giulio FERRIGNO (giulio.ferrigno@santannapisa.it)
Web Page: www.santannapisa.it/it/giulio-ferrigno

Objectives
This advanced course aims at providing students with knowledge of the main topics and management practices characterizing today's competitive environment. A special emphasis will be put on the role of enabling technologies and on management practices in innovative firms. The course will also introduce students to entrepreneurial practices in information science (how to develop and bring to the market new products and services based on embedded systems and high-tech solutions).

Syllabus
1) The innovative firm: theoretical concepts and management implications
– Knowledge, invention and innovation.
– Technological paradigms: nature and evolution.
– Sources of innovation.
– Innovation typologies and dynamics.
– Innovation diffusion and market barriers.
– The innovative firm: resources, competencies and boundaries.
– Quantitative indicators of innovative activities.
– Innovation and firm growth.
– The geography of R&D: knowledge and innovation.
– Entrepreneurial practices in information science.
2) Management practices and enabling technologies
– Technological paradigms in information science.
– Architecture machine (r)evolution and firms' organization.
– Software (r)evolution and firms' key competencies evolution.
– Network (r)evolution and firms? boundaries.
– AI (r)evolution and Industry 4.0.

Project design & management for data science (1075I) (6 ECTS)
Semester: 1
Contact Person: Prof. Filippo CHIARELLO (filippo.chiarello@unipi.it)
Web Page: didawiki.di.unipi.it/doku.php/mds/d4ds/start

Objectives
The goal of the course is to introduce students to practical tools and methods to design and manage data science driven projects. Students will learn and apply tools coming from design theory, to be used in every DS phase,from problem understanding to results communication. The course will fill the existing gap in students? competences, to be able to structure unstructured problems, similarly to what they will be asked in their future job positions. Each topic will teach the students a clear tool to be used from day 1 in their projects. The course will end with a series of "Design for" lessons to place the content in a specific context (i.e. I4.0, sustainability, equality).

Syllabus
Project design module:
– Soft Skills: what they are and why are they important for a DS project. The concept of not-so-soft skills.
– Business Problem Identification: Types of business problems, sources for business problems identification.
– Research Questions Design: Types of RQs, writing proper RQs.
– Problem Setting: From questions to problems.
– Problem Solving: Tools and techniques for problem solving.
– Project Scoping: Define the scope of the analysis. Definition of stopping criteria.
– Goal Design: How to define goals.
– Measures Design: Process Indicators VS Result Indicators.
– Information Retrieval: Find the right information [Query Design].
– Team Design: Find and mix the right competencies for a DS Project [Bloom's Taxonomy].
– Design for I.4.0: what is industry 4.0, the main technologies, future developments.
– Design for Sustainability: how data can be used to design green products.
– Design for Gender Equality: avoid gender biases in DS. The case of biased AI systems.
– Design for post COVID-19 word: How COVID-19 is reshaping DS.
Project management module:
– Fundamentals: projects and processes.
– Project planning and WBS.
– Scheduling techniques [GANTT, PERT, CPM].
– Project costing estimation.
– SCRUM & Agile methodologies for data science projects.

Strategic and competitive intelligence (787II) (6 ECTS)
Semester: 2
Contact Person: Prof. Filippo CHIARELLO (filippo.chiarello@unipi.it)
Web Page: esami.unipi.it

Objectives
CI programs have goals such as proactively detecting opportunities or threats, eliminating or reducing blind-spots, risks and/or surprises; and reducing reaction time to competitor and marketplace changes. The end product of any worthwhile CI activity is what practitioners term *actionable intelligence*, i.e. intelligence that management can act upon. It is more than analysing competitors: it is a process for gathering information, converting it into intelligence (about products, customers, competitors, and any aspect of the environment) and then using it in decision making. In this sense, big data brings big change to CI. The course includes in-class seminars that introduce the fundamentals of competitive intelligence, including systems and strategic thinking. It provides many tools and techniques. Students will apply these tools in groups when analysing a preselected case company. They are expected to present early stage versions of their reports and, in the final workshop, they will present the results of their CI analysis, which is then discussed in plenary.

Syllabus
Part 1: Foundations of competitive intelligence
– Systems thinking for management.
– CI process.
– Sources and collection techniques.
– CI professionals.
Part 2: Competitor and Market intelligence tools
– Competitive benchmarking (to assess competitive cost of operations, to analyze the true capabilities of a rival, as well as its immediate future actions).
– Early warnings and blindspots.
– Business ecosystems (value network analysis).
– Advanced tools: scenario analysis, war gaming.
Part 3: Technology intelligence tools
– Intellectual Property Rights and patenting activity.
– Patent analysis and Bibliometrics analysis.
– Technology foresight.

A.4 Elective subjects from the GR3 group

Legal issues in data science (381NN) (6 ECTS)
Semester: 2
Contact Person: Prof. Giovanni COMANDÈ (giovanni.comande@sssup.it)
Web Page: esami.unipi.it

Objectives

The digital economy and the digital society harness the power of big data, computational capacity, innovation and interconnection. Every human activity is mediated by information technologies. Today's technologies enable unprecedented exploitation of information, being it small or big data, for any thinkable purpose, but mostly in business and surveillance with the ensuing legal and ethical anxieties and constraints. Algorithms are regularly used for mining data, offering unexplored patterns and deep non-causal analyses to those businesses able to exploit these advances. Yet, these innovations need to be properly framed in the existing legal background, fit in the existing set of guarantees of fundamental rights and freedoms, coherently policy related to reap the richness of big and open data and administration while empowering equally all players. For these aims data protection plays a significant role The course aims at enabling students to work on algorithms and data mining techniques in ways that are compliant to the applicable legal framework and aware of the interplay between techniques and normative rules.

Syllabus
The Algorithmic Society: the Classifying Society
– Background and Overview, Surveillance Society
– Big Other, Networks of Control, Predicting Behavior
– People Analytics, Behavioural "Nudging"
– New Emerging Human Rights in the age of Behavioral Data Science and Neurotechnologies
– Towards "Mental Privacy" and "Decision Integrity"
– Legal and ethical implication of computational capacity.
Building Legally-Compliant Algorithms:
– Legal Pitfalls of Algorithms, The Problems of Personalization, Data Handling & Sharing,
– Deploying Algorithms for Human Rights: Complications & Challenges
– Classification of Algorithms in the Information Society
– Legal Implications and Business Applications, Exploitation of Public Sector Data
– Competition Law in the Age of Algorithms, Transparency
– Accountability and traceability of algorithm based decision-making
– Accountability in the Machine Learning Context
– Technical and Legal Options to Enhance Transparency & Accountability
– Legal Liability for Algorithm Autocomplete (ISP Liability)
– Open Data Governance, Data Ethics.
General principles of privacy law: The American approach, The European approach.
The General Data Protection Regulation:
– Notions and principles, GDPR global reach and compliance
– Google Spain Decision
– Invalidation of Data Retention Directive (US Safe Harbour Decision)/Schrems.
Privacy in operation
– Privacy-by-Design, GDPR Solutions: The Right to an Explanation, etc.
– Notions of Privacy in the Algorithmic Age, Privacy from the Government
– Surveillance Capitalism, Governance by Proxy, Privacy from Private Entities
– Privacy from Platforms, Privacy from Employers, Privacy from our Devices (IoT).
Comparative Perspectives & Crossborder Issues:

– Comparative Privacy and security Regimes: GDPR vs. USA
– Comparative Privacy and security Regimes: GDPR vs. China.

Model-driven decision-making methods (666AA) (6 ECTS)
Semester: 2
Contact Person: Prof. Bartosz FILIPECKI (bartosz.filipecki@unipi.it)
Web Page: elearning.di.unipi.it/enrol/index.php?id=972

Objectives
The course will enable the student to produce and/or appropriately use software tools for the support to complex decisions (mainly at the corporate/industrial level) based on mathematical optimization techniques. The course is focussed on practical aspects of these tools. The main aim is to familiarize the students with the specific computer science aspects of these activities, such as data preparation and validation, the development of complex mathematical models, the knowledgeable use of the corresponding solution algorithms, the impact on this process of data uncertainty and the available methodologies to tackle this problem.

Syllabus
– Decision theory, decision processes.
– Architecture of decision support systems.
– Reminds to the theory of Linear Programming and Integer Linear Programming problems.
– Solvers of Linear Programming and Integer Linear Programming problems.
– Methodologies for improving performances of the algorithms.
– Data uncertainty issues within optimization methods.

Programming for data science (667AA) (12 ECTS)
Semester: 1
Contact Person: Prof. Salvatore TRANI (salvatore.trani@isti.cnr.it)
Contact Person : Prof. Laura SEMINI (laura.semini@unipi.it)
Web Page: didawiki.di.unipi.it/doku.php/mds/pds/

Objectives
This is an introductory course to computer programming and related mathematical/logic background for students without a Bachelor in Computer Science or in Computer Engineering. The objective is to smoothly introduce the student to the programming concepts and tools needed for typical data processing and data analysis tasks. The course consists of lectures and practice in computer labs.

Syllabus
– Sets, relations, functions, combinatorics, grammars, automata.
– Propositional and first order logic.
– Induction and recurrence relations.
– Imperative programming.
– Object oriented programming.
– Programming stack and development tools.

A.5 Elective subjects from the Table 2.4 group

The subjects from Table 2.4 of the *Informatics* area are offered by the Master Degree program in Computer Science. Detailed information will be available at the website:

www.di.unipi.it/en/education/mcs

Important notice: the timetable of these subjects will not be included in the official timetable of the Data Science and Business Informatics programme. Please, check the website above for timetables.

Corsi in Italiano

This appendix reports the syllabus of the courses offered in Italian. Details on each course are available at the Course Catalogue:

https://unipi.coursecatalogue.cineca.it/corsi/2024/11357/insegnamenti/52766

and the web page of the course.

B.1 Attività formative a scelta del gruppo GR2

Analisi e gestione dei costi* **(265PP) (9 ECTS)**
Title in English: Cost Analysis and Management
Semester: 2
Contact Person: Prof. Riccardo GIANNETTI (riccardo.giannetti@unipi.it)
Web Page: esami.unipi.it
Obiettivi
Il corso ha lo scopo di approfondire alcuni aspetti della determinazione dei costi e di trattare le principali logiche e tecniche per la gestione dei costi a supporto delle decisioni.

Syllabus
– L'analisi e la gestione dei costi e il processo decisionale.
– Approfondimenti sull'ActivityBased Costing.
– L'ActivityBased Management.
– La gestione della profittabilita' del cliente.
– I costi ambientali.
– I costi della qualita'.
– Il target costing.

Diritto dell'informatica* **(058NN) (6 ECTS)**
Title in English: Law and Computer Science
Semester: 1
Contact Person: Prof. Giulia PULEIO (giulia.puleio@unipi.it)
Web Page: esami.unipi.it

Obiettivi
L'avvento delle tecnologie informatiche ha sollevato problemi per la regolamentazione giuridica delle attivita' compiute loro tramite. Il corso si propone di analizzare queste problematiche, considerando sia le regole giuridiche specifiche per l'era digitale sia la possibilita' di impiego del diritto generale. In particolare, il corso si propone di esaminare, tra alcune grandi tematiche del diritto nell'era digitale, quelle piu' proprie del contesto aziendale, ossia la contrattazione telematica, il documento informatico, il trattamento dei dati personali e le responsabilita' in Internet.

Syllabus
– Il commercio elettronico. Conclusione, validita', forma e prova del contratto concluso via email e tramite point and click: applicabilita' delle regole generali, deroghe e regole speciali. La Direttiva europea sul commercio elettronico e la sua attuazione: il d.lgs. n. 70/2003. I contratti ad oggetto informatico.
– La tutela del consumatore e il regime delle informazioni in rete: informazioni generali, commerciali e pubblicitarie non sollecitate ("spamming"). Le informazioni pubblicitarie nelle professioni regolamentate.
– La disciplina del trattamento
dei dati personali (d.lgs. n. 196/2003). Il trattamento dei dati personali: nozione di trattamento, dato personale, titolare, responsabile, incaricato, interessato.
L'informativa e il consenso. Il trattamento effettuato con l'ausilio degli strumenti elettronici. La sicurezza dei dati: il documento programmatico sulla sicurezza e il disciplinare tecnico. Il regime sanzionatorio civile, amministrativo e penale.
Il trattamento in outsourcing dei dati personali.
– Firma digitale, firma elettronica e documento informatico: questioni di forma, validita' e prova. La posta elettronica certificata. La trasmissione telematica dei documenti. I certificatori.
– I domain names. I nomi di dominio aziendali. Le regole della Registration Authority.
– Gli illeciti in Internet e la responsabilita' dei providers.
– La tutela del software. Software libero e software proprietario. Il diritto di autore all'epoca di Internet.
– L'elaboratore e l'adempimento dell'obbligazione: la moneta elettronica e i mezzi di pagamento in Internet.

Economia e gestione delle imprese* - Corso B - (049PP) (9 ECTS)
Title in English: Business Management
Semester: 2
Contact Person: Prof.ssa Antonella ANGELINI (antonella.angelini@unipi.it)
Program Page: esami.unipi.it

Obiettivi
Il corso fornisce gli elementi analitici di base per comprendere il comportamento d'impresa. Tratta le principali tematiche economicomanageriali, le logiche di base e gli strumenti relativi alla gestione strategica delle imprese e all'analisi dell'ambiente competitivo. Gli obiettivi formativi sono:

- Conoscere le principali teorie che spiegano i fattori che influenzano la redditivita' di impresa.
- Acquisire una conoscenza introduttiva delle dinamiche di organizzazione della produzione industriale, e di come essa sia cambiata nel tempo.
- Acquisire conoscenze di base degli strumenti di marketing che le imprese hanno a disposizione per aumentare la propria competitivita'.
- Sviluppare o rafforzare la capacita' critica e di pensiero individuale. Il corso intende infatti evitare l'apprendimento passivo e acritico dei temi oggetto di studio.

Syllabus
Parte I (L'analisi di settore e del sistema competitivo)
- L'analisi di settore.
- L'analisi dei concorrenti.
- I gruppi strategici.
- Le risorse e le competenze nella formulazione strategica.
- L'analisi del vantaggio competitivo (il vantaggio di costo e di differenziazione).

Parte II (L'analisi dell'impresa e delle sue funzioni.
Un focus su produzione e marketing)
- Produzione.
- Strategia innovativa e flessibilita' dell'impresa.
- Il modello di flessibilita' dei sistemi tecnicoproduttivi.
- Marketing.
- Il processo di marketing management.
- La segmentazione del mercato.
- Il marketing mix (prodotto, promozione, distribuzione e prezzo).

Organizzazione aziendale* - Corso A - (357PP) (9 ECTS)
Title in English: Business Organization
Semester: 2
Contact Person: Prof. Marco GIANNINI (marco.giannini@unipi.it)
Web Page: esami.unipi.it
Obiettivi
Lo scopo di questo corso è di fornire una spiegazione realistica di come funziona una moderna organizzazione. L'obiettivo formativo e' di sviluppare un pensiero critico, un atteggiamento interrogativo e una capacita' analitica riguardo ai problemi organizzativi.

Syllabus
– Strategia e risposte all'incertezza ambientale.
– Variabili strutturali per la progettazione organizzativa in differenti contesti empirici.
– Relazioni interorganizzative.
– Impatto della tecnologia sull'organizzazione.
– Ciclo di vita di una organizzazione.
– Meccanismi di controllo organizzativo.
– Cultura ed etica organizzativa.

Pianificazione e controllo gestionale* **(278PP) (9 ECTS)**
Title in English: Management Control
Semester: 1
Contact Person: Prof. Nicola Giuseppe CASTELLANO (nicola.castellano@unipi.it)
Web Page: esami.unipi.it

Obiettivi
Il corso si propone di approfondire le caratteristiche della pianificazione e controllo evidenziando tanto l'evoluzione nella dottrina che nella strumentazione operativa a supporto del management.

Syllabus
– Il sistema di controllo.
– Il processo, i meccanismi operativi e lo stile di controllo.
– Le variabili del controllo.
– Il processo di budgeting.
– L'analisi degli scostamenti.
– I contenuti ed il processo di reporting.
– L'analisi reddituale e patrimoniale.
– La leva operativa e la leva finanziaria.
– La simulazione economico-finanziaria.
– Il processo di simulazione: le simulazioni di efficienza e di struttura.
– Gli aspetti evolutivi del budget.
– Il modello di previsione, simulazione e pianificazione SISMA.
– Casi aziendali.

B.2 Attività formative a scelta del gruppo GR3

Ingegneria del software* **(271AA) (6 ECTS)**
Title in English: Software Engineering
Semester: 2
Contact Person: Prof.ssa Laura SEMINI (laura.semini@unipi.it)
Web Page: didawiki.di.unipi.it/doku.php/informatica/is-a

Obiettivi
Fornire le metodologie e strumenti per la progettazione, realizzazione, verifica, validazione e misurazione di sistemi software.

Syllabus
– Processo di sviluppo software: problemi della produzione del software, modelli di ciclo di vita.
– Analisi del dominio: modelli statici (classi e associazioni) e dinamici (attivit a, macchine a stati).
– Analisi dei requisiti: modello statico (casi d'uso) e dinamici (narrative, diagrammi di robustezza).
– Progettazione architettonica: modelli statici (viste strutturali e logistiche) e dinamici (vista componenti/connettori).
– Progettazione di dettaglio: modello statico delle componenti (strutture composite) e modello dinamico (interazioni).
– Verifiche e prove: obiettivi e pianificazione delle verifiche, progettazione e valutazione delle prove.