POLITECNICO
MILANO 1863

DIPARTIMENTO DI
INGEGNERIA GESTIONALE

MASTER OF SCIENCE IN MANAGEMENT ENGINEERING

COURSE SYLLABI
2023-2024

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096078 Accounting, Finance and Control
(10 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Students are required to know the basics of:

- Financial Accounting
- Cost Accounting
- Management Accounting
- Long- and short-term decision making

The potential knowledge gaps can be bridged with these (not mutually exclusive) sources:

- Open Online Course "Fundamentals of Financial and Management Accounting" (mandatory for all AFC students – except those holding a Bachelor in Management Engineering achieved at Politecnico di Milano)
- The following chapters/annexes of the textbook "Performance Measurement and Management for Engineers":
  - eAnnexes to the book (freely available online)
  - eAnnex 2: Financial Accounting
  - eAnnex 3: Cost Accounting
  - Chapter 7 (Long- and short-term decision making)"

Learning Objectives

The course 'Accounting Finance & Control' (AFC) aims at providing students with the state-of-art, theoretical framework and instruments to measure and manage the overall performance of a (for profit) enterprise. The course fits into the overall program curriculum pursuing some of the expected learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modelling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

At the end of the course, students will know and understand:

- The main methods for reporting and assessing the financial and non-financial performance of an enterprise, as well as the main linkages among them
- The organisational role of the "Accounting, Finance and Control" Units in an enterprise and its evolution over time

- The goals, the structure and the processes of the Planning & Control (P&C) Cycle
- The motivational implications of the use of management control tools

Students will be able to:

- Apply the methods and models discussed during the course to real cases (e.g., to enterprises that belong to different sectors or have different organizational structures)
- Design tailored performance measurement systems (e.g., systems that match the goals and the peculiarities of real enterprises)
- Prepare performance reports tailored to the information needs of different stakeholders
- Read and interpret the financial (and non-financial) performance of an enterprise (and of its constituencies)

Topics Covered

- The "Accounting, Finance and Control" (AFC) domain: the role of financial accountants and controllers and its evolution over time
- The "AFC" organizational unit within the enterprise
- The main activities performed by the "AFC" organizational unit (Advanced) Financial Accounting: the concept of corporate group (or "group of companies"). Consolidated Financial Statements: theories and consolidation methods
- (Corporate) Performance Measurement
- Accounting-based Performance Measures. The application to a real case: the analysis of consolidated financial statements of a business group
- Value Based indicators: Discounted Cash Flow techniques. Enterprise Value vs. Equity Value. The calculation of Free Cash Flows. The discounting factor: the cost of capital. Relative Valuation.
- Value Drivers (non-financial performance measures and risk indicators) The integrated Planning & Control Cycle
- The "Planning" phase: the elaboration of operating, capital and cash flow budgets, and financial planning.
- The "Control" phase: periodic management reporting. The structure and content of management reports. Corporate dashboards and balanced scorecards.
- Measuring and reporting performance of internal responsibility centres.
- The performance of internal profit/investment centres (Business Units, Divisions). Corporate costs allocation and transfer pricing.

Bibliography

Main textbook

Arnaboldi, A. Azzone, G. and Giorgino, M. (2014) "Performance Measurement and Management for Engineers" Elsevier.

Recommended material

Anthony R. and Govindarajan V. (2006) "Management Control Systems" McGraw-Hill Higher Education.

Gavin Lawrie and Ian Cobbold “Development of the 3rd Generation Balanced Scorecard” 2GC Active Management

Kaplan R.S. and Norton D.P. (1993). “Putting the Balanced Scorecard to Work”, Harvard Business Review.

Simons, R. (1995) Control in an age of empowerment. Harvard Business Review (March-April): 80-88

097313 Additive Manufacturing
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No specific pre-existing know-how is required.

Learning Objectives

The low-volume production of parts with highly complex geometries has long been regarded as an economically unfeasible task with traditional manufacturing processes. Such belief is now changing due to the introduction of Additive Manufacturing (AM) processes, often referred to with the collective term of 3D Printing. This course will introduce the AM processes and their applications, discussing their technical and business-oriented implications for designers, engineers, “makers” and other possible users of this advanced manufacturing technology.

Expected Learning Outcomes

After successfully completing the course, the student will be able to:

- Redesign x AM, having a correct landscape of all the principal AM processes (pros and cons), carry out a cost-and-value analysis of substituting current technologies with AM ones (Knowledge and understanding skills)
- Identify trends, technologies and key methodologies related with digital and advanced manufacturing in the Industry 4.0 framework (Applying Knowledge).
- Develop new ideas and solutions in emerging industrial businesses. In fact, Additive manufacturing is one of the more active playgrounds for new solutions, innovative ideas and start-ups. (Applying knowledge and making judgements)
- Interact in a professional, responsible, effective and constructive way in a working environment. The project work will allow all the students to interact in a multi-disciplinary environment. In fact, the project team will mix students in management, mechanical, design, automation and physics engineering (Team-working and communication abilities).

Topics Covered

Introduction. Layer-by-layer principle. Benefits and limitation of AM. Historical development of AM technology. Generalized AM process chain. Materials and industrial applications: rapid prototyping, rapid tooling, direct digital manufacturing. Process selection, market availability and trends, business opportunities. AM technology: Polymers. Description and modeling of the main AM processes for polymers. Machines, software issues, post-processing, design for. AM technology: Metals. Description and modeling of the main AM processes for metals. Machines, software issues, post-processing, design for.

AM product verification. The need for precision metrology. Dimensional and geometrical metrology for AM: limits of tactile and optical measuring systems; volume-based measuring systems: 3D X-ray computed tomography. Surface topography measurement (tactile, optical, other, analysis methods).

AM process monitoring. The need for precision processing. In-line monitoring for AM: process variables measurement, monitoring approaches, sensor and data fusion.

Bibliography

Main textbook

Ian Gibson, David Rosen, Brent Stucker, Additive Manufacturing Technologies, Editor: Springer, New York, NY, ISBN: 978-1-4939-2112-6 available as eBook on biblio.polimi.it

055893 Advanced Mathematical Models in Finance
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Basic knowledge of finance, probability and mathematical analysis.

Learning Objectives

The course will allow the student to:

- Design an asset management strategy;
- Understand equilibrium and no arbitrage pricing techniques;
- Understand mathematical models for risk management

Expected Learning Outcomes

After the course the student will**:**

- Build the portfolio frontier and define an asset management strategy;
- Know equilibrium and no arbitrage pricing techniques;
- Know the main concepts of stochastic calculus, which are essential in quantitative finance;
- Know how to price and hedge a financial derivative;
- Know how to solve analytically (if possible) a financial problem (asset management, pricing, hedging), exploiting the developed theoretical competencies;
- Know how to find proper modeling assumption to describe a financial asset (stock, interest rate, volatility, commodities, etc.);
- Know how to manage risk of financial derivatives.

Topics Covered

1. Decisions in a risky environment (2 hours)
2. Portfolio and insurance decisions (2 hours)
3. Portfolio frontier (2 hours)
4. Asset management: from theory to practice (2 hours)
5. Derivatives evaluation (2 hours)
6. Equilibrium models (2 hours)
7. Introduction to stochastic processes (2 hours)
8. Option pricing (2 hours)
9. Interest rate models (2 hours)
10. Risk management of derivatives (2 hours)

The course will include exercise sessions in which examples and applications of the general theory to specific concrete cases will be provided and discussed working on real data.

Bibliography

Main textbook

Teaching notes

Barucci, Marazzina, Nencini, Finanza matematica, Editor: Egea

056984 Advanced Modeling for Operations
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Students are required to have a basic knowledge of Production and Logistics Operations and the basics notions of statistics. Students that do not have this basic knowledge will be provided with references and material (e.g. slides, MOOCS) to fill the gap.

Learning Objectives

The course aims to provide students with the capabilities to master advanced modeling for operations in order to face management problems in different systems of interest. It will lead to the virtualization of the studied systems into different types of simulation models through which the decision-makers can conduct experiments, thus learning about the complex systems and helping the design of more effective decision-making structures and operating policies.
The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members.

Expected Learning Outcomes

- Understand the different concepts of simulation for analysing operations problems and foster the introduction of innovation solutions and practices in complex systems and real-life business contexts
- Understand the use of simulation tools exploiting general programming languages or mathematical and simulation environments which allows improving analytical skill and mindset
- Apply criteria, models and tools to operations problems in order to provide the decision-making support considering different types of decisions (strategic, tactical and operational), various scopes (e.g. supply chain and single node of a logistics and production network), and multiple objectives (e.g. efficiency, sustainability, resilience)
- Model and design innovative solutions in new fields (e.g. Industry and Logistics 4.0)
- Improve team-working skills

Topics Covered

1. Simulation technique. Types and paradigm of simulation. Simulation objectives. Design and development of a simulation model. Generating probability distributions (Monte Carlo simulation). Design of experiment campaign.
2. Event-oriented simulation. Modeling, analysis and design of complex systems (e.g. production systems) through event-oriented simulation paradigm.
3. Object-oriented simulation. Modeling, analysis and design of complex systems (e.g. supply chain and logistics systems) through object-oriented simulation paradigm.
4. Simulation-based intelligent support systems for decision-making. Use of simulation to develop decision support systems in smart processes (e.g. synchronized use of simulation with physical operations according to the Digital Twin approach).

Each topic is treated both theoretically and above all practically. In particular, the course intends to provide the skills to develop simulation models using the Python general programming language.

The course leverages the following teaching methodologies:

- Theoretical lessons, to provide the students with both knowledge on the modelling of complex systems and criteria, methodologies, models and tools to design and manage operations problems (ILOs 1, 2)
- Practical lessons, to go through structured exercises to let the students apply what they learnt during the theoretical lessons (ILOs 2, 3 and 4)
- Laboratory sessions, to go through assignments to let the students apply what they learnt during the theoretical lessons and work in small groups (ILOs 2, 3, 4 and 5)
- Seminars, i.e. lectures given by external guests (managers and consultants to present the use of simulation to solve real-life business problems) to provide the students with strong connections with the real applications of what has been learnt during the lessons (ILOs 1, 2, 4)

Bibliography

Main textbook

The teaching material consists of: (i) set of slides supporting the in-class lectures; (ii) practical lessons/exercises; (iii) selected references (selection of papers and chapters of relevant books, etc.). All the material will be available before the related lesson on https://beep.metid.polimi.it.

Recommended material*

Averill, M. Law, Simulation Modeling and Analysis, Mc Graw Hill Education

Kinder, J.M. and Nelson, P., A Guide to Python for Physical Modeling, Princeton

Gordon, S.I. and Guilfoos, B., Introduction to Modeling and Simulation with MATLAB® and Python, Routledge

Ciaburro, G., Hands-On Simulation Modeling with Python, Packt

*These references are not mandatory to successfully take the exam. They are just a recommendation for autonomous in-depth study.

057045 Advanced Performance Measurement
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

The subjects covered in the course Accounting, Finance and Control are prerequisites for this course.

Learning Objectives

The course "Advanced Performance Measurement" aims to provide students with state-of-art tools, advanced data analytics methodologies and real-case applications to manage performances in an organization.

The course contributes to the development of the following capabilities:

- Understand how organizations run performance measurement systems and their overlapping with data analysis;
- Understand and apply proper data analysis techniques to support plan, lead and control activities and processes of organizations considering the different decision makers and challenges within an organization;
- Design solutions to face performance management issues and opportunities, applying data modelling, analysis and visualization techniques, based on rigorous reasoning and modelling capabilities.

Expected Learning Outcomes

At the end of the course, students:

- Will know and understand who are the different decision makers, the different approaches and challenges within an organization when it comes to monitoring performance and defining goals;
- Will be able to understand what are the enabling technologies to run an advanced performance measurement system and use proper data analytics techniques and tools to improve the planning control cycle in all its phases;
- Will be able to define and monitor different KPIs, to develop managerial reports and dashboards for different decision makers within an organization and to deliver and interpret data insights.

Topics Covered

The course is organized in the following units:

- Introduction to the course. Definition of Advanced Performance Measurement
- How performance management and data analysis within an organization relate with:
  - different decision makers
  - different models for advanced performance measurement
- The enabling technologies for performance measurement:

    - The digital transformation journey and the mega trends by which companies are reinventing themselves
    - The major technologies which are empowering the decision-making process
- Data analytics tools and techniques:
    - Machine Learning: overview of main data analytics techniques
    - Data treatment: cleaning and pre-processing data
    - Supervised Learning: regression and classification
    - Unsupervised Learning: clustering
- Business intelligence and performance measurement:
    - Data analysis within the planning and control cycle
    - Data visualization
- Risks and ethics of an Advanced Performance Measurement system.

Bibliography

No texts suggested.

057301 Advanced Supply Chain Planning Lab
(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

- Fundamentals of Operations Management
- Fundamentals of Supply Chain Management

Learning Objectives

The global business environment and the increased complexity in supply chain planning require an extended set of competences, ranging from new collaborative planning methods to advanced IT tools. In this scenario, the Lab objective is to provide state-of-the-art knowledge on management practices, techniques and tools for advanced Supply Chain planning tasks, including also some topics about Supply Chain Execution. By mixing traditional theoretical lessons, business games and application cases, guest speakers, hands-on lab sessions and a company-based project work, a set of thorough yet practical skills will be transferred to the students.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Identify trends, technologies and key methodologies in a specific domain
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating other group members

Expected Learning Outcomes

Given the above-mentioned learning goals, the following learning outcomes are expected:

- Knowledge of the state-of-the-art challenges, practices and tools related to the task of planning complex supply chains. E.g.: the relevance of financials performances in planning, the most used practices to enhance collaboration, data exchange and risks sharing in supply chains, the available technologies in the IoT arena, the adoption of cloud platforms and application to collect data and to enable business integration. These elements will have to be known both in general terms, as well as contextualized (knowing relevance/priority) in specific industries;
- Capability to use basic (e.g. MS Excel) and advanced (e.g. r) tools to analyse data so as to support planning related-decision, e.g. data preparation, integration and cleaning, basic clustering, time series analysis, etc.

- Capability to analyse, redesign and improve a real SC planning process, starting from the detailed map of the current process of a company (activities, tools, responsibilities) and the quantitative assessment of the current performances, then moving to the identification of criticalities (process, organization, technology), then re-designing all of the above mentioned process elements, including the assessment of cost/benefits and the definition of a roadmap to implement the new process (considering organizational, technological, financial, regulation etc. constraints).
- Capability to accomplish several (i.e. parallel) demanding tasks during the semester, managing stress, working in multi-language & multi-cultural team, interacting with external company stakeholders and respecting deadlines in internal (for the teacher) and external (for the company) deliverables.

Topics Covered

The Lab program will encompass the following contents:

- Introduction / reprise about supply chain planning tasks, examples from different industries; the relevance of information in nowadays planning.
- Models and techniques for advanced planning: from Vendor Managed Inventory to Supply Chain simulation.
- Technologies for Advanced Planning: APS systems, Internet of Things, Industrial Analytics and Artificial Intelligence, Cloud IoT platforms, Cloud SaaS and related ecosystem, blockchain;
- Tools: data analytics for planning, fundamentals of "r" and its application to planning problems
- Methodologies for Value Assessment: a framework for tangible and intangible benefits, approaches and models for a quantitative assessment, and for business case constructing
- Industries and vertical markets: depending on the availability of guest speakers, focus on Advanced planning in the following industries: Automotive, Retailing, Food, Construction and Fashion Luxury
- Outlook on the job market: the role of human planner in the future technology playground.

Each topic will be first introduced through a short traditional lesson, and then followed by extensive applicative contents. Overall, the Lab will resort to the following teaching methodologies:

- Traditional lessons, providing theoretical background, scenario analysis, outlook on market needs and technology solutions;
- Business cases, so as to practice with specific planning problems, techniques and tools in limited-size problems. Students' presentations will enhance presentation skills and will be used to assess the degree of involvement with the proposed contents
- Computer aided learning (e.g. business games)
- Visit to the Internet of Things Lab of Politecnico di Milano (if allowed by logistic constraints)
- Company guest speakers
- Autonomous work on assignment(s) (both thematic and company project work)

Bibliography

Several recommended readings, mostly academic papers and business research reports will be uploaded/recommended during the course, also depending on current business trends and on the selected guest speakers.

057044 Agile Innovation
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

The course actively engages students in an experiential learning process: in addition to conceptual inputs, the faculty will use case study discussion, workshop, teamworking sessions and team presentations. For this reason, it requires that participants:

- Attend class regularly and contribute to class discussions;
- Be fully prepared for class (by accomplishing the pre-assigned tasks);
- Actively participate in team projects and activities outside of class, and contribute to team learning.

The main educational process is thought for students who will actively participate in class and who will engage in team-bases activities. The course allows some students, who are not able to provide this form of active participation, an alternative educational process.

Attending students.

The course is based on both individual and team activities. The lectures manly aim at illustrating and sharing frameworks, models and tools. In order to facilitate the understanding, case studies are presented and discussed along the lectures. During the course, participants develop the Team Design Sprint Project adopting the Design Sprint approach to face the brief proposed by the Faculty.

Each participant belongs to a self-selected team defined at the beginning of the course. The teams are averagely composed by 6-8 members. The Team Design Sprint Project is based on five main phases:

- Map: the first phase is based on interviews with users and experts as well as observation of the addressed experience autonomously developed by each team aimed at clearly defining the challenge;
- Sketch: the second phase is supported by the Faculty who facilitates the Sketch and Decide Factory (design workshop aimed at creating innovative solutions and based on one dedicated session);
- Decide: the third phase is supported by the Faculty who facilitates the Sketch and Decide Factory (design workshop aimed at identifying the most promising innovative solutions and based on one dedicated session);
- Prototype: the forth phase is supported by the Faculty who facilitates the Prototype Factory (design workshop aimed at developing the prototypes to test and based on one dedicated session);

Test: the fifth phase is based on test sessions autonomously developed by each team aimed at learning from users and improve the innovative solution.

The *Individual Written Exam*, scheduled at the beginning of the off-term period (1st call), is composed by small case studies to be critically reviewed, closed and open questions.

Not-attending students.

Not-attending students are those who — for some major constraints [e.g. Interns, Erasmus, etc.] that should be clearly explained to the faculty by email — are not able to participate to more than 50% of classes and/or team activities. Students with overlapping classes should commit in participating to Design Thinking for Business activities within the abovementioned limit or follow the course as not-attending students.

The exam is oral and scheduled in the off-lectures period. Not-attending students will not be included in teams and have to develop the Individual Design Sprint Project: this activity substitutes the Team Design Sprint Project that attending students accomplish in teams. The Individual Design Sprint Project is about the same brief proposed to the teams along the course. The Individual Design Thinking Project is presented during the oral exam.

The selected brand must be communicated and agreed with the faculty, by sending an email to both Claudio Dell'Era (claudio.dellera@polimi.it) and Stefano Magistretti (stefano.magistretti@polimi.it) at least 2 weeks before the end of the semester. The Individual Design Sprint Project is presented during the oral exam. Not-attending students have to prepare only a Power Point presentation about the project to be presented during the oral exam in maximum 15 minutes.

The Faculty strongly suggest to attend classes and to engage in team activities. An active participation to the course not only improves the effectiveness of the learning process, but also reduces the overall effort that the student has to put in the preparation of the final exam characterizing the course.

Learning Objectives

- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment;
- Develop new ideas and solutions in business and industrial scenarios evolving over time.

Expected Learning Outcomes

- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
    - Manage design practices and making capabilities in accelerating innovation projects [Individual Written Exam];
- Develop new ideas and solutions in business and industrial scenarios evolving over time;
    - Early prototype innovative concepts [Team Design Sprint Project];
    - Manage uncertainty of innovation projects adopting agile approaches [Team Design Sprint Project].

Topics Covered

Today's world, where speed is gaining increasing relevance to make innovation happen, has called for the emergence of approaches that leverage continuous testing and iteration. After the introduction of the Agile Manifesto in 2001, a wide range of industries has experienced the massive diffusion of Agile approaches. These approaches leverage agility, flexibility, and the rapid development of new solutions. On the one hand, Agile emerges as a tool to change the development process; on the other, it emerges as a culture to embrace flexibility. Especially this cultural aspect is crucial in agile innovation approaches. Design is recognized as a powerful approach to reduce uncertainty; more specifically several studies show that adopting a design mindset can help embracing ambiguity and foster innovation even when the problems are wicked and ill-defined. In discovering new technologies, knowledge and uncertainty are always high, and the search for the right application might require different and complex iteration and experimentation processes. Design Sprint represents a new approach deeply rooted on agile culture, design attitude and experimentation mindset. It aims at accelerating innovation by the adoption of sketching, testing and prototyping tools.

The course has been designed around the following main topics:

- Agile Culture: Making innovation happen in a continuously changing environment where ambiguity, variability and complexity is raising requires new mindset and approaches. Thus, agile innovation is gaining traction as a culture to cope with these shortcomings, in promoting both an agile culture and tools to make innovation happen. Furthermore, lean development and lean start-up are approaches that are getting more and more relevance in today's panorama not only in hi-tech industries. Agile methodologies and specific approaches such as SCRUM are fundamental to properly manage innovation projects in turbulent environments;
- Design Attitude: The emergence of new paradigms such as human-centered design, participatory design and design thinking, have marked the transforming role of design in the field of innovation management. Design is not only an aesthetic driver of innovation but represents a new set of innovation management practices. It is something practiced not only by designers but by everyone in organizations who seeks to innovate;
- Experimentation Mindset: Innovation approaches, such as agile development, and lean start-up, may differ on some principles and practices, but they have one key ingredient in common: experimentation. Recent approaches leverage experiments for exploratory learning. In particular, "quick & dirty" prototypes are used to search the most valuable innovation opportunities. The changing nature of experimentation in innovation is supported by the digitalization trend. The increasingly digital nature of products and services facilitates early, less expensive, higher-fidelity prototypes and the subsequent tests.

Bibliography

Recommended materials

Knapp J, Zeratsky J, and Kowitz B, Sprint: How to solve big problems and test new ideas in just five days, Editor: Simon and Schuster, Anno edition: 2016

Iansiti M, and Lakhani KR, Competing in the age of AI: strategy and leadership when algorithms and networks run the world, Editor: Harvard Business Press, Anno edition: 2020

Ries E, The Lean Start-up: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, Editore: Crown Business New York, Anno edition: 2011

Ries E, The Start-up Way: How Modern Companies Use Entrepreneurial Management to Transform Culture and Drive Long-term Growth, Editore: Currency, Anno edition: 2017

Thomke SH, Experimentation matters: unlocking the potential of new technologies for innovation, Editore: Harvard Business Press: Boston, Anno edition: 2003

Thomke SH, Experimentation Works: The Surprising Power of Business Experiments, Editore: Harvard Business Press: Boston, Anno edition: 2020

Cooper RG and Sommer AF, The Agile-Stage Gate Hybrid Model: A Promising New Approach and a New Research Opportunity, Editore: Journal of Product Innovation Management, Anno edition: 2016

Dell'Era C, Magistretti S, and Messeni-Petruzzelli A, How intelligent is Watson? Enabling digital transformation through artificial intelligence, Editore: Business Horizons, Anno edition: 2019

Magistretti S, Trabucchi D, Buganza T, and Dell'Era C, A New Path Toward a Hybrid Model: Insights from PwC's Italian Experience Centre, Editore: Research-Technology Management, Anno edition: 2019

Magistretti S, Dell'Era C, and Verganti R, Look for New Opportunities in Existing Technologies: Leveraging Temporal and Spatial Dimensions to Power Discovery, Editore: Research-Technology Management, Anno edition: 2020

Magistretti S, Dell'Era C and Doppio N, Design sprint for SMEs: an organizational taxonomy based on configuration theory, Editore: Management Decisions, Anno edition: 2020

Magistretti S, Allo L, Verganti R, Dell'Era C, and Reutter F, The micro foundations of design sprint: how Johnson & Johnson cultivates innovation in a highly regulated market, Editore: Journal of Knowledge Management, Anno edition: 2021

Magistretti S, Pham C, and Dell'Era C, Enlightening the dynamic capabilities of design thinking in fostering digital transformation, Editore: Industrial Marketing Management, Anno edition: 2021

Nambisan S, Lyytinen K, Majchrzak A, and Song M, Digital Innovation Management: Reinventing innovation management research in a digital world, Editore: Mis Quarterly, Anno edition: 2017

Pham C, Magistretti S, and Dell'Era C, The Role of Design Thinking in Big Data Innovations, Editore: Innovation: Organization & Management, Anno edition: 2021

Verganti R, Vendraminelli L, and Iansiti M, Innovation and Design in the Age of Artificial Intelligence, Editore: Journal of Product Innovation Management, Anno edition: 2020

057072 Agile Project Management

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

The course aims at developing the competences necessary to apply the basic Project Management techniques and tools to a complex project. In increasingly volatile markets, project management needs special attention including change-enabling methodologies into traditional processes. Consequently, the course deals with the traditional (or plan driven) processes of project planning and control (scope, time, resource, cost, quality, risk, cash flow, stakeholder, communication...) and with Agile (or change-driven) project management processes that facilitate the management of project scope changes. The waterfall and agile tools and techniques seen in class will be practiced with two approach:

- The analysis of case studies of projects carried out in traditional sectors (Oil & Gas, plant engineering, nuclear, energy).
- The participation to a hackathon where each groups' project work will be presented to an external commission

The course fits into the overall program curriculum pursuing some of the defined general goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

By the end of the course, students will learn contents and practices according to what defined in the Learning Objectives.

Use properly Plan Driven & Change Driven Project Management language, understanding management processes involved in a project, understanding interdependencies between operational and managerial processes, capability to correctly apply techniques and tools available in project management.

In terms of acquired knowledge and understanding, students will be able to develop with both traditional and agile methodologies plans for managing different types of complex project involving the main knowledge areas of project management (scope of work, time, progress, cost, resources, cash flow, risk, etc.) and to estimate project performance and evaluate recovery plans during project execution.

Concerning the ability to apply the acquired knowledge and understanding, students will be able to select the methodology (plan driven or agile) that best suit different types of projects.

Through the project work development students will also acquire the skills to formulate a judgment, on implementing an effective two-way communication: with colleagues for the development of the project work, with the managers of the companies involved in the competition for the participation to the hackathon.

Finally, students will improve their communication skills, being able to communicate both with other students during the project work development and with professionals during the final hackathon.

Topics Covered

- Managing projects with Agile methods: Project anticipation and adaptability to change; traditional, iterative, incremental and agile project's lifecycles. Differences between agile and waterfall methods, need to develop new process to cope with change and instability, the context of application of Agile tools & Techniques.
- The Agile Manifesto: History, origins and field of application.
- Individuals and interactions over processes and tools: principles of effective communication and iteration.
- Working software over comprehensive documentation: the key roles of iteration and prototyping activities.
- Customer collaboration over contract negotiation: structuring an effective collaboration with client.
- Responding to change over following a plan: Including change in the project planning phase.
- The 12 principles of managing project in an Agile field: Definition and analysis of the 12 main values that are the basis of agile.
- Working with Agile: The Agile Project management lifecycle, the triple constraints triangle.
- Reviewing the main Agile Frameworks: Lean software development: The seven principles of software development
- Extreme Programming: Values, principles and practices
- Working in Scrum: Vision; Product Roadmap; Release planning; Sprint Planning; Daily Scrum; Sprint Review; Sprint Retrospective.
- Agile Earned Value: measuring project progress in an agile context
- Tool & techniques of Agile Project Management: communication area, Planning monitoring and control area, agile estimation, interpersonal skills, risk management, value-based prioritization.
- The role of the scrum master: principle of servant leadership in action.

Bibliography

Rory Burke, Fundamentals of Project Management, Editore: Burke Publishing, Anno edition: 2017, ISBN: 9780994149213

Mauro Mancini, Costanza Mariani, Quantitative Tools for a Smart Project Management, Editore: Esculapio, Anno edition: 2021, ISBN: 9788893852548

055771 Agri-Food Supply Chain Perspectives
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

The course aims at providing knowledge and tools to understand some fundamental concepts regarding the Food Ecosystem, thus including food supply chains as well as society, environment, and other public and private stakeholders. Agri-food supply chains will be introduced and analysed under a strategic design lens, with focus on supply chain strategies and configurations. The course will also introduce two key performance dimensions for modern agri-food supply chain: sustainability and quality. Sustainability practices and transformation as well as different dimension of food quality and their implications for the food supply chain will be introduced and discussed. Moreover, students will be introduced to examples of real supply chains in different food industrial segments, in which relevant and specific sustainability challenges and transformation will be analysed from a theoretical as well as from a practical perspective, through seminars by companies' speakers.

Teaching is delivered by a mix of:

- Lectures and introduction of theoretical frameworks
- Discussion of case studies
- Seminars from companies, other institutions and academic experts in specific domains
- Workshops on food sustainability index

Expected Learning Outcomes

At the end of the course the students will be able to:

- Understand the concept of supply chain and supply chain management
- Describe the main typologies of food supply chains in terms of industry overview, main actors and key processes
- Understand, describe and analyse the types of supply chain strategies and the main models for global supply chain configurations (for non-food and food products)
- Understand and describe the main trends and challenges connected to sustainable development and the grand challenges connected to the food industry
- Understand the complexity, analyse and apply sustainability assessment of global food systems.
- Understand principles of the circular economy paradigm, main business models and practices.
- Understand the key principles and challenges connected to different dimensions of food quality and regulations and their implications for the agri-food supply chains

Topics Covered

1. Introduction to the concept of supply chain, supply chain management
2. Decision phases in supply chain management
3. Strategic network design:
   - Supply chain strategies
   - Global supply chain configurations
4. Sustainability in the agri-food supply chain:
   - Definition of sustainability and the SDGS framework
   - The role of the supply chain: threats and opportunities
   - Sustainable supply chain strategies and practices, sustainability-oriented innovations and collaborations
   - The transition towards Circular economy:
     - Circular economy principles and business models
     - Circular economy in the food industry: the food waste hierarchy framework
5. Food quality and regulations in the agri-food supply chain
   - The food quality heptagon model
   - Traceability in agri-food supply chain
   - Food quality and sustainability through sustainable food packaging solutions
   - The role of EFSA – food regulations and verification mechanisms
6. Supply chain configurations and managerial challenges in the agri-food supply chain for various industrial segments and products (e.g., fruits and vegetables; animal protein supply chain, etc.).

Bibliography

Recommended materials

Samir Dani, Food Supply Chain Management and Logistics - From Farm to Fork, Editore: Kogan Page, Edition: 2015

Sunil Chopra, Supply Chain Management - Strategy, Planning and Operations, Editore: Pearson, Edition: 2019 (Only chapter from 1 to 6 and 17)

057054 Analytics for Business Lab

(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Solid background in statistics is particularly useful. Basic knowledge of SQL and R or similar languages and/or of statistical tools and software (e.g., SPSS, Stata, etc.) may facilitate the learning process. The contents of the courses "Advanced performance measurement" and "Marketing Analytics" will be considered as pre-requisites for the lab.

Learning Objectives

The course intends to allow students to work hands-on on top-notch, concrete issues in analytics for business. Through a strong collaboration with companies and the possibility to work on real cases, the intended objective of the lab is to:

- Introduce advanced methods for managing analytics for marketing and performance management
- Allow students to apply these methods and the others studied in the stream and the study course in real contexts in order to identify effective, viable and reliable solutions to actual problems
- Encourage an understanding of the actual needs and problems of companies when approaching issues related to data-powered decision making in different aspects of their business

Expected Learning Outcomes

- Understand challenges, functions, processes in a business and industrial environment and their mutual effects on business, economy, environment and society
- Identify trends, technologies, key methodologies and stakeholder needs in analytics for business
- Interact in a professional, responsible, inclusive, effective and constructive way in a working environment, also motivating group members

Topics Covered

The course will consist of three main parts:

1. Advanced analytical methods: seminars to introduce top-notch methods and advanced tools to address marketing and performance management real problems, combining a technical introduction and a discussion of their applications, complementarily to what has already been analysed in the other stream courses. A particular emphasis shall be put on the investigation of the causal nature of the relationship between variables, boing beyond mere correlation;

2. Seminars with practitioners: testimonials from the business community will take part in the classes to show their experiences and discuss with participants the real issues they deal with in their day-to-day job;

3. Lab: students will form groups and be provided with a detailed outline of a business scenario, a dataset to ground their analysis and will be required to develop, in team, a concrete, viable and effective solution applying analytical methods encountered in the stream. During the lab, tutors will deepen the tools and methods required for the solution, also by running ad hoc deep dives and exercises. In the final part of the lab, groups will present their result to the representatives of the companies that will provide the cases and the datasets in order to get also their feedbacks.

With respect to the advanced analytical methods, the topics addressed will be:

- Statistical Natural Language Processing (SNLP) for text classification:
  - Text representations and distributional semantics
  - Singular Value Decomposition and Non-negative Matrix Factorization
  - Latent Semantic Analysis
  - Probabilistic LSA
  - Sentiment Evaluation
  - Sentiment Classification
- Anomaly Detection Methods (methods for identifying outliers, frauds or other non-standard situations)
  - Traditional statistical approaches: z-scores, IQR, IQR-alpha, …
  - Advanced statistical methods: Gaussian Mixture Models, Independent Component Analysis (ICA), Regression-model based
  - Ensemble Methods: Isolation Forests
  - Reconstruction and subspace-based Methods: AE, PCA
  - Classification Methods: One-class SVM
- Advanced Market basket analysis (beyond support, confidence and lift, to dig into the underlying association rules)
  - Frequent Itemset Mining
  - Association Rule mining
  - Statistical evaluation of Association Rules, other measures of "interestingness" for AR
  - Contrast set learning
  - Sequence Analysis
- Advanced Graph/Network theory (for social network analysis, recommendation engines, etc.)
  - Types of Graphs and Graphs as Data representations
  - Node Classification: label propagation
  - Link Prediction: topology-based (common neighbours, Katz measure, preferential attachment, …), probabilistic methods (hierarchical structure model)
  - Network Clustering: stochastic block models
  - Graph Embedding: factorization-based (Laplacian eigenmaps, inner-product methods), random walk-based methods

Bibliography

Recommended materials

Samir Dani, Food Supply Chain Management and Logistics - From Farm to Fork, Editore: Kogan Page, Edition: 2015

Sunil Chopra, Supply Chain Management - Strategy, Planning and Operations, Editore: Pearson, Edition: 2019 (Only chapter from 1 to 6 and 17)

052911 Applied Statistics
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

A basic course in Statistics for Engineers.

Learning Objectives

The course covers new approaches in the areas of statistical modeling and data analysis, using ideas that bridge the gap between statistics and computer science and developing tools for the statistical mining of big data. The focus is on predictive learning, with particular emphasis on recent advances in regression and classification. The course takes advantage of a blended learning approach, making extensive use of the Statistical Learning MOOC by Hastie and Tibshirani referenced in the Bibliography. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

At the end of the course students are expected to be able to design and run with R a data driven analysis aimed at a classification problem, both supervised or unsupervised, or at the fitting of a regression model, handling classical (OLS, Logistic regression) or more modern approaches to model building and selection (ridge regression and lasso, CART, random forests). Leveraging on their engineering forma mentis and on the skills in data analysis acquired in the course, students are expected to be able to evaluate the practical and statistical significance of the final result of their data analysis, to quantify its uncertainty, e.g. by applying cross-validation procedures, and to diagnose its potential shortcomings, either when used to provide an empirical explanation of the industrial or scientific problem under study or when its main goal is to formulate predictions. To prepare for responsible and efficient interactions in a working environment, every student is required to take part in a real data analysis project developed by an independently formed team of 2-4 members. The work in progress of the projects will be collectively discussed during general meetings scheduled along the course; final analyses and results will be presented in a workshop which will take place at the end of the course.

Topics Covered

Program:

1. Introduction to statistical learning.
2. Dimension reduction. Principal Component Analysis.

3. Linear Models. Simple and multiple linear regression. Estimating the coefficients, assessing the accuracy of the coefficient estimates, assessing the accuracy of the model. Qualitative predictors. Model selection and regularization: subset selection, shrinkage methods (ridge regression and lasso), dimension reduction methods.
4. Supervised classification. Logistic regression. Linear and Quadratic discriminant analysis.
5. Unsupervised classification. Hierarchical clustering, K-means clustering.
6. Resampling methods. Cross-validation. The bootstrap.
7. Tree-based methods. Classification and regression trees. Bagging, random forests, boosting.

Following a blended learning approach, the course will make extensive use of the Statistical Learning MOOC by Hastie and Tibshirani referenced in the Bibliography. All methods will be illustrated using applications from marketing, finance, biology and other areas; the R free software environment for statistical computing and graphics (downloadable at www.r-project.org) will be used and illustrated throughout the course and its lab sessions. Through the course, students are required to work in team on a real data analysis project whose progress will be shown periodically to the class.

Bibliography

No texts suggested.

097362 Branding and Communication

(6 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

This course can be followed from students selected in the ambit of the Double Degree Project Product Service System Design/Management Engineering.

Learning Objectives

During this course, Students are expected to mainly develop the following characteristics:

- Have an analytical mindset and analytical skills able to integrate creative and managerial attitudes
- Ability to apply a specialized set of skills and competencies in all the aspects of value creation within the branding process

Develop teamwork skills as a key characterizing aspect of working in global and multicultural companies.

Expected Learning Outcomes

Student are expected to :

- know and understand the theoretical foundations for decoding and managing a brand identity;
- know how to interpret the nature of a brand by transferring its values into visual and stylistic codes to be used in brand management and strategy planning;
- be able to manage, plan and coordinate brands and product portfolios in relation to communication, retail and media planning.

Topics Covered

The course will be delivered in blended mode through the fruition of a specific MOOC by all students and activities delivered both on line and in class (https://www.pok.polimi.it/courses/course-v1:Polimi+DIGIM03+2021_M1/about).

The MOOC addresses basic knowledge pillars of branding processes with a specific focus on cultural industries (CCIs) and fashion in particular as a crucial and advanced context for analyzing emerging branding strategies within the current digital transformation.

The course will address the following subjects:

Theoretical background

The integration of models belonging to semiotics to understand how to build up or decode a brand identity through the values it represents and how they are perceived and interpreted by final customers.

Brand & design management

From brand identity to brand expressions: translating brand DNA into visual and stylistic codes and managing their different expressions into products, services and communication.

Brand portfolio management: managing different brands reaching different target markets properly managing brand DNA codes not overlapping product/service portfolios.

Product portfolio management: planning and managing products portfolios to balance carryovers and research-oriented products, enhancing markets potential while efficiently planning categories' in depth and range.

Process planning: planning brand & product management phases and timing and integrating them with parallel processes (ex. communication and retailing).

Communication design & management

From brand management to communication management: translating brand DNA into visual and communication codes constituting the "Corporate Identity".

Communication design development: translating visual codes into different artefacts for different media (analogic VS digital)

Retail planning: translating brand DNA into visual codes and languages applied into different retail chanels, both physical and digital.

Theoretical contents will be supported by case studies and will find applications in two assignments students will develop during the course.

Bibliography

Recommended materials

A specific list of readings will be provided during the course

052909 Business & Industrial Economics

(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Basics of economics: on-line course on Economics (Microeconomics) freely available on the POK (Polimi Open Knowledge) platform at www.pok.polimi.it.

Learning Objectives

This course presents the major principles of industrial economics normally taught to Master of Science students in Economics and Engineering schools. The course provides models of firms' competition and of the functioning of industries. Students will acquire knowledge on theories of the firm, competitive structures, entry barriers, market failures, externalities, economics of innovation and technological change, industrial and competition policies. The concepts will be presented from the double point of view of firms competing on the markets and of policymakers who supervise and regulate this competition. Such an approach will teach students to make sense of the heterogeneity of real-world industries' structures and of the consequences of this heterogeneity on firms' profits, competitive dynamics, and, more generally, social welfare. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance.
- Develop new ideas and solutions in business and industrial scenarios evolving over time.
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

Know concepts and definitions about the components and impacts of business and institutional contexts on firms' conducts and performance.
Understand models and economic rationales that explain how the business context causes business conducts, firm performance and social welfare.
Apply the instruments provided in the course to the analysis of real-world cases and industries to enhance managerial and policy-making decision making.

Topics Covered

Efficiency, coordination, and economic organization
Why do firms and industries exist? The role of specialization, exchange, coordination; Efficient allocation of resources (general equilibrium and welfare economics); Coordination mechanisms: the invisible hand of markets and the visible hand of firms and institutions.
Competitive structures
Insights into different market forms; Concentration and concentration indices; Regulation of natural monopoly.

Market failures
Market power: allocative inefficiency; Externalities: consumption and production externalities, remedies to externalities, network externalities; Public Goods; Information asymmetries: moral hazard and adverse selection, remedies to information asymmetries: signals and incentives; Transaction costs: bounded rationality, specific investments, opportunistic behavior; Transaction costs and governance of transactions.
Oligopolistic markets
Strategic interdependence and duopolistic models; Entry barriers, entry deterrence and limit pricing; Price discrimination; The theory of contestable markets: on the conditions for potential competition and on the existence of perfectly contestable markets.
Theories of the firm and their implications
The neo-classical profit maximization assumption: critiques and alternatives; Theories of the firm: managerial theories, contractual perspectives (agency theory, property rights theory), resource- and knowledge-based theories; Determinants and insights into firm boundaries: horizontal and vertical integration, diversification, mergers & acquisitions, alliances and other intermediate forms between firm and market; Determinants of internationalization and the multinational corporation.
Technological change and innovation
Theories of technological change: the legacy of Schumpeter; Market structure and innovation; The economics of standards: hardware/software paradigm, winner-takes-all-markets and technological standard wars.
Industrial and competition policy
Classification of policies: industrial policy, regulation and antitrust; The economics of anti-trust (market power analysis, collusion and cartels, predatory pricing and exclusionary practices); The economics of ex-ante regulation (road "map" to regulation, first- and second-best solutions; asymmetric information and regulation: cost-plus, price-cap, yardstick competition); Industrial policy: approaches and experiences.

Bibliography

No texts suggested

057042 Business Design and Transformation Lab
(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

There are not binding pre-requisites to attend the Lab.
Basics of strategy, Innovation, Design and Leadership will be useful for developing the project.

Learning Objectives

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance.
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment.
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members.

Expected Learning Outcomes

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
    - Extrapolate the business needs from a specific situation/context and summarize a list of requirements to be matched in order to fulfil those needs
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
    - Generate and develop an innovation proposal impacting the business and, at the same time, identify the related business and organizational transformations needed to implement the innovation. Finally integrate both plans to achieve both business innovation and transformation
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members
    - Drive the team-work in a professional environment interacting both with team mates and professors, and with professionals in the companies providing the brief

Topics Covered

What does it mean to re-design and transform a business? How can we move from a vision to an actioned new purposeful organization? Introducing an innovation (like a new product or service) is difficult but still more straightforward than transforming a business. Changing the very nature of a company goes beyond designing and manufacturing new products and/or developing and delivering new services. An automotive company wanting to enter the mobility arena with car-sharing; a postal company introducing financial branch; or a software company wanting to develop strategic consultancy skills to help its customers correctly assess the business value of the technological solutions they provide, are possible examples of what we mean by Business Transformations. These transformations are difficult to be conceived. They require to have a vision, to scout the human and social mega-trends, to interpret the changes in users' behaviours, and to create new solutions. Besides that, though, they will also challenge the way people work inside the company. If you want to do radically different things, you must be different yourself. People in the organization must change their skills but also their mindsets. This human transformation is hard-wired into the business re-design and transformation, and no business transformation can survive without helping people in the company to transform themselves.

The Lab leverages the rules of project-based learning. It will provide a business (re)design and transformation experience, proposing a business transformation live experience. It will be developed either with the innovation and transformation department of corporations or with consulting companies helping corporations to achieve a major business transformation and to make it really happen.

The knowledge acquired in previous courses regarding strategy, design thinking, vision and change, leadership, etc. will be seamlessly integrated into a single effective and agile process.

Students will work in teams to design the answers to the brief proposed by companies. The project development will require to interact with the managers in the real field through interviews and project review meetings. Each team will design and develop a workshop with external stakeholders to either investigate the customers' needs, validate the proposed solution, or trigger the transformation, helping people move towards the new direction. Finally, teams will also co-operate to design the overall experience collaborating with the professors to share methodologies and tools already used in previous courses but possibly not known by part of the team members.

Bibliography

No texts suggested.

097673 Calculus of Variations

(8 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Basic Mathematical Analysis courses of Laurea Triennale in Ingegneria.

Learning Objectives

Aims and scope -

Problem solving for optimization problems and minimization of integral functionals: deduction, manipulation and solution of Euler equations and variational problems connnected to conditions of extremality.

Basic knowledge of variational inequalities and their formulation aiming to deal with constrained problems.

These topics will be presented in the perspective of their relevant applications to problems in Mathematical Physics and Engineering.

The teaching activity of this course includes lecture hours and training sessions.

Expectations of achievements and abilities resulting from a successful attendance of this course are those associated with the Dublin Descriptors DD1, DD2, DD3, DD4.

Expected Learning Outcomes

The course provides an introduction to modern techniques in Calculus of Variations and Geometric Measure Theory. Minimization of integral functionals is studied in connection with variational formulations of boundary value problems for differential equations and problems with unilateral constraints. Some applications to continuum mechanics and image analysis are presented.

Topics presentation is focused on the acquisition and critical use of main tools in: Calculus of Variations, Functional Analysis, optimization of integral functional with and without constraint, Euler equations, interplay of integral minimization with variational formulation of PDEs and variational inequalities.

Lecture hours will allow students to know and understand the topics above (DD1) and to apply their knowledge and understanding (DD2, DD3).

Training sessions will allow students to become familiar with the theoretical concepts presented during lecture hours (DD1, DD2, DD3), and help developing ability to make judgements, and improve communication skills (DD3, DD4) to be tested by an oral examination.

Topics Covered

The top 10 core topics of the course can be summarized as follows:

1. Dido's problema. Steiner's problem. First variation of an integral functional.

2. Classical Calculus of Variations. Euler-Lagrange equations. First integrals. Null-lagrangian integrals. The direct method in Calculus of Variations.
3. Isoperimetric inequality. Wirtinger inequality. Laplace equation. Mean value property. Bounded slope condition. Hilbert Theorem concerning Lipschitz extremals.
4. Friedrichs mollifiers. Sobolev spaces. Poincaré inequality. Traces. Convexity of integral functionals. Semicontinuity of integral functionals. Sobolev embeddings.
5. Reflexivity. Separability. Weak coinvergence. Weak-star coinvergence. Banach-Alaoglu-Bourbaki Theorem. Elliptic equations in divergence form. Clamped plate. Elasticity system.
6. Variational inequalities in Hilbert spaces. Lions-Stampacchia Theorem. Minimum problems with convex constraints. Noncoercive problems. Recession cone. Obstacle problem for membrane and plate.
7. Measures. BV functions of one or several variables. Absolutely continuous functions.
8. Hausdorff measure. Hausdorff dimension. Hutchinson's self-similar fractal sets. Rectifiable sets. Federer-Vol'pert Theorem. Cantor-Vitali function.
9. Finite perimeter sets. First variation of area functional and mean curvature. Mumford-Shah functional: strong and weak formulation.
10. Gamma-convergence. Definitions and examples.

Bibliography

Recommended materials

Luigi Ambrosio, Nicola Fusco, Diego Pallara, Functions of Bounded Variation and Free Discontinuity Problems, Editore: Clarendon Press, Anno edition: 2000
Heidy Attouch, Giuseppe Buttazzo, Gérard Michaille, Variational Analysis in Sobolev and BV Spaces, Editore: MOS-SIAM, Anno edition: 2014
David Kinderlehrer, Guido Stampacchia An Introduction to Variational Inequalities and Their Applications, Editore: SIAM, Anno edition: 2000
Haim Brezis, Analisi funzionale, Editore: Liguori, Anno edition: 1986
Franco Tomarelli, Mathematical Analysis Tools for Engineering, Editore: Esculapio, Anno edition: 2021
Mariano Giaquinta, La forma delle cose, Editore: Edizioni di Storia e Letteratura, Anno edition: 2010

057018 Circular Economy Business Models

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

The course has no specific pre-requisites, even if a good understanding of strategy & marketing concepts will help in contributing to classes.

Learning Objectives

The course aims at guiding the learner on the theme of Circular Economy through a deliberate alternation of practical cases and application examples to a more theoretical view of the phenomenon. The core of the course is the design and evaluation of business models, either of established companies willing to embrace the new paradigm or of start-ups and new ventures born on a Circular Economy idea.

Particular attention will be paid to the pervasiveness of the paradigm, with examples and good practices relating to several business sectors.

Expected Learning Outcomes

Students will learn:

- The core meaning of Circular Economy in business environment, being able to properly recognize and distinguishing circular business models from "green", "ESG" or "sustainable" business models;
- The tools and frameworks to design and evaluate a circular business model, in different industries;
- The tools and frameworks to analyse the context and the ecosystem around a circular business model, with particular reference to the role of regulations and of digital technologies in enabling circularity.

Moreover, students will be engaged in lively debates with entrepreneurs and managers in the field of Circular Economy, thus allowing also a deeper understanding of the enablers and barriers to the diffusion of the new paradigm.

Topics Covered

The top 10 core topics of the course can be summarized as follows:

1. The Genesis of the Circular Economy concept, the main differences between Circular Economy and Linear Economy. Circular Economy and Sustainability
2. The basic frameworks for understanding Circular Economy: the butterfly model and the RESOLVE model
3. The CE Matrix (Upstream-Downstream-Full Circular) and the classification of Circular Economy business models.
4. Cases of adoption of Circular Economy in established companies and in start-ups
5. The “Circular” Business Model Canvas: designing a successful transition towards Circular Economy
6. The enabling role of IT & IoT in the transition towards Circular Economy

7. The "platform" business models in the Circular Economy
8. Financing Circular Economy
9. The role of catalysts and of the context in developing Circular Business Models
10. Circular Cities and Circular Ecosystems: adopting a broader perspective for the diffusion of the Circular Economy paradigm

The course is intended to be based on lively discussions and participated classes. In-course team works will be required.

Teaching material consists in slides (ppt format) and case studies. Further references to complementary material (books, articles extracted from scientific journals, reports by research centres, other readings) will be provided during the classes.

Additional materials can be found at the Ellen Macarthur Foundation Learning Hub (https://www.ellenmacarthurfoundation.org/explore).

Bibliography

No texts suggested.

057016 Circular Economy Lab
(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Students are expected to know the principles of circular economy, key CE strategies, principles of circular business model. These topics are covered in courses ‘Circular Industrial Systems’ and ‘Circular Economy Business Model’.

Learning Objectives

Climate change, environmental pollution, resource scarcity are the contemporary challenges that call for urgent transition of the industry from the traditional paradigm of production and consumption towards circular economy and sustainable development. This course is designed to provide students with the concepts and instruments necessary for a) identifying circular economy strategies relevant in different industrial contexts; b) analysing the impact of CE strategies on economic, environmental and social performance of the industry; c) analysing the transition from linear to circular economy. The emphasis is given to the systemic perspective in examination of circular economy approaches at company and industrial system levels.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) coupled with participatory approaches to face problems and opportunities in a business, industrial and societal environment
- Develop new ideas and transformative solutions to deliver positive impact on business, industrial and societal scenarios evolving over time
- Interact in a professional, responsible, inclusive, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

The student that has successfully attended the course is expected to be able to:

- Identify circularity improvement opportunities and apply CE strategies relevant to a specific business/industrial context
- Analyse the impact of CE strategies on improvement of circularity and economic, environmental and social performance of a company/industry
- Analyse the transition from linear to circular economy
- Present solutions and ideas in a professional and constructive way, fostering the value of the teamwork, and using a language adequate to both managers and fellow students

Topics Covered

The lab contents:

- Circular economy strategies: how circularity can be achieved, trade-offs and limitations of CE strategies
- Circular business models: how the profit can be generated based on the CE strategies, related enablers (e.g., digital platforms)
- Circularity performance: circularity indicators and environmental impacts of CE strategies in short and long-term
- Circular business cases evaluation: methods and tools for the economic assessment of CE strategies
- Transition process towards the circular economy: challenges, trade-offs and opportunities, lock-ins and path-dependency related to the application of CE strategies

The lab organization

The lab leverages the following teaching methodologies:

- Traditional lessons, providing theoretical background
- Simulation-based business game
- Individual and group work on exercises
- Group work on a company problem (project)
- Seminars with company guest speakers

Bibliography

Slides and other classroom materials will be available on the Beep website of the course https://beep.metid.polimi.it

057017 Circular Industrial Systems

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

This course does not require any specific prior knowledge of the topic.

Learning Objectives

Climate change, environmental pollution, resource scarcity are the contemporary challenges that call for urgent transition of the industry from the traditional paradigm of production and consumption towards circular economy and sustainable development. This course is designed to provide students with concepts and instruments necessary for analysing industrial practices in terms of their environmental performance, and for identification of relevant circular economy strategies for decoupling economic growth from environmental degradation, increasing resource efficiency and promoting sustainable lifestyles. The emphasis is given to the systemic perspective in examination of circular economy approaches at company and industrial system levels.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand challenges, functions, processes in a business and industrial environment and their mutual effects on business, economy, environment and society
- Identify trends, technologies, key methodologies and stakeholder needs related to circular economy at company and industrial system levels
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modelling capability deriving from a solid and rigorous multidisciplinary background) coupled with participatory approaches to face problems and opportunities in a business, industrial and social environment

Expected Learning Outcomes

A student that has successfully attended the course is expected to:

- Understand the role of circular economy in enabling the decoupling of economic activities from negative environmental impacts and fostering the transition towards sustainable development
- Know and explain circular economy strategies and their limitations at company and industrial system levels
- Identify and apply appropriate instruments for analysing circularity and environmental impact of industrial operations
- Critically analyse industrial practices and identify opportunities for improving their circularity

Topics Covered

Basics of circular economy: industrial ecology, sustainable development, principles of circular economy, limitations of circular economy, circular economy strategies

Circular economy at the company level: circular product design, product/material end-of-life management: reuse, remanufacturing, recycling

Circular economy at the industrial system level: reverse and closed-loop supply chain management, industrial symbiosis

Circularity and environmental impact analysis instruments: circularity indicators, environmental key performance indicators, material flow analysis, life cycle assessment

The course is organised in lectures (traditional and flipped classroom formats), discussion of case studies, in-class exercises, “In the Loop” gaming session.

Bibliography

Slides and other classroom materials will be available on the Beep website of the course https://beep.metid.polimi.it

057026 Collaborative Innovation for Sustainability and Impact
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

This course aims at achieving the following learning goals:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify future trends, technologies and key methodologies in the domain of sustainable innovation

Expected Learning Outcomes

At the end of the course, students will be able to:

- Understand the relevance of sustainable innovation for the long-term success of a firm
- Understand the importance to work in a cooperative way with the involvement of all the key stakeholders to effectively implement a sustainable oriented innovation
- Identify the role played by technologies and new approaches for the implementation of a sustainable oriented innovation

Topics Covered

In order to tackle the Learning Objectives mentioned above, the course will cover the following topics.

The role of sustainability for innovation: this first chapter aims at presenting the role that sustainability is nowadays playing as a source of innovation for companies. In this chapter of the course, we will cover the following topics:

- The new challenge of sustainable development as source of innovation
- What is a sustainability-oriented innovation
- The innovation process for sustainability
- The new types of collaborations for sustainability

New models of innovation for sustainability: the second chapter of the course aims at investigating the new models of innovation, with a clear purpose towards sustainability, such as business model innovation for sustainability, product innovation for sustainability, frugal innovation, retro-innovation, supply chain innovation for sustainability.

Enablers of innovation for sustainability: the third chapter of the course aims at presenting the main necessary enablers to implement innovation for sustainability. In particular, the following enablers will be investigated:

- the role of technology for sustainable innovation and impact
- the role of organization to manage innovation for sustainability
- the role of certification

- the role of public-private partnership

Collaborations for sustainability: the fourth chapter of the course aims at illustrating the important role played by collaborations with different stakeholders in order to implement innovation for sustainability. In this chapter we will investigate why it is important to collaborate for sustainability and how this could be realized, which are potential framework to use and which are the forms of cross-sectoral collaborations. In this final chapter, we will also investigate the meaning and the goal to collaborate with different types of stakeholders, such as companies and competitors, customers, suppliers, start-ups, employees, not for profit, etc.

Bibliography

No texts suggested.

057049 Complex Projects LAB

(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

Managing complex projects is about transforming “a vision” into a “reality”. It is about designing and building a new transportation or energy infrastructure, a bridge or a house, or even find and deliver a cure for Covid. Project Management is an incredibly interdisciplinary topic. Cost estimation of new engineering systems, communication management in temporary organisations, financing infrastructure investments, social and environmental sustainability are all common topics in project studies that are widely applicable across stakeholders, such as companies and government. This course aims at transferring to students the key empirical elements to work in the Project Business. The key goals are enabling students to:

- Bring together and apply the concepts learned in other courses of this major to deal with large engineering projects and project business challenges.
- Apply tools and techniques learned in other more theoretical courses to real and pseudo-real scenarios in project ecology
- Gain the soft and hard skills to evaluate, plan and manage complex projects

Expected Learning Outcomes

After successful completion of this module, students:

- Will demonstrate the ability to identify and analyse the key elements of complex projects and project-based companies, eventually discussing planning and delivery strategies (Knowledge and understanding);
- Will be able to select and apply proper qualitative and quantitative tools and techniques at different project life cycle stages (Applying Knowledge and understanding);
- Will be able to critically evaluate real projects, identify key elements, such as stakeholders, risks, costs and benefits (Making Judgements and Learning skills), and prepare a technical report describing the best course of action for decision-makers (Communication).

Topics Covered

The course enables students to apply the state-of-the-art approaches, methods and models for deciding, planning, and delivering complex projects. There are four key elements in this course:

- Interaction with industry and practitioners: A number of industrial guests will be invited in the module to expose students to real-life experiences. Each guest will introduce him/herself explaining his/her experience with project business. He/she will present his/her company, its role in the project ecology. One or more real projects will be presented and discussed with specific questions/challenges proposed to the students and debriefed with the expert.

- Guest lectures: Academics or Experts will be invited to lecture on relevant topics related to complex projects which are not covered in other modules. Examples of these topics might include: governance of Special Purpose Entities (SPE), Future-proofing infrastructure, Mental Health in Projects. Each lecture will include both theory and activities for students
- Case studies: A series of case studies of the duration of a lecture will be proposed to the student. Each case study will require students to develop a critical analysis applying tools and techniques learned across the major and present an ideal solution/strategy to deal with this case
- Development of a major coursework. Students will be required to develop a major coursework concerning a real complex project planned or delivered in Italy or abroad. The students will critically evaluate this project, present their findings to hypothetical decision-makers, and will prepare a report. This will be group work, and a certain number of lectures will be devoted to introducing the coursework, provide feedback during the development and present the final results. Company managers will be involved as tutors.

Bibliography

Main textbooks

Teaching notes, scientific papers, Case texts and suggested readings by the instructor (available on Beep course web page).

"Project Management: Achieving Competitive Advantage" by Jeffery Pinto, Pearson; 5th edition, 2019.

056994 Corporate Finance
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

- Knowledge of cash flow discounting methodologies;
- Knowledge of the balance sheet structure (A&L, profit&losses, cash flow statement);
- Knowledge of the Capital Asset Pricing Model (CAPM).

Learning Objectives

The course objectives are as follows:
- Analysing the financial structure and governance decisions of a company
- Learning how the company may raise money to finance growth, projects and investments, and which instruments can be used
- Analysing the characteristics of financial securities, and their valuation methodologies
- Analysing derivatives contracts, their valuation methodologies and how they can be used to hedge company liabilities

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:
- Understand context, functions, processes and instruments in firm and investment financing
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in corporate finance
- Develop new ideas and solutions in financial modelling

Expected Learning Outcomes

- Comprehension of the logics of the firm financial structure, selecting between equity and debt
- Demonstrate the knowledge of the characteristics and pricing models of debt and equity securities
- Capability to evaluate the effects of financing decisions on firm and investment appraisal, designing solutions and models
- Demonstrate the knowledge of the characteristics and pricing models of derivatives (forward contracts and options) and their use in hedging strategies

Topics Covered

The course of Corporate Finance (5 CFU) analyses the process of corporate investments' financing through the selection of security typology, capital issuance, corporate governance and hedging. Topics:
- Financial structure: Modigliani & Miller propositions, debt vs. equity, agency costs

- Debt raising: bonds (valuation, duration, term structure of interest rates, volatility)
- Equity raising: shares (valuation)
- Interactions between value and financing (adjusted present value, wacc)
- Derivatives (forward contracts, options)

The course may be taken as optional by students enrolled in any concentrations of the course of Management Engineering.

Bibliography

Recommended materials

Brealey Myers, Principles of Corporate Finance

055806 Critical Thinking

(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

The Course Critical Thinking aims to provide in an innovative manner the methodological tools necessary to reason and argue in a sound way under conditions of risk and uncertainty in science and technology. The tools used will be those belonging to logic, philosophy, argumentation, and psychology of thought applied to uncertain reasoning. The course contents will be presented and discussed interactively with the students. The Course is intended to give students a chance to critically reflect on cultural, social, and ethical impacts of science and technology.

Expected Learning Outcomes

- (Knowledge and understanding)
  Students will:
  - be acquainted with different forms of scientific reasoning
  - acquire methodological skills in order to deal with risk and uncertainty
- (Applying knowledge and understanding)
  Students will:
  - foster their ability to solve problems and cope with uncertainty
  - apply critical thinking to wicked problems
  - integrate their technical knowledge with humanistic, cognitive and ethical perspectives on science and technology
- (Making judgements)
  Students will be able to:
  - use methods and imagine scenarios in order to deal with (severe) uncertainty
  - enhance creativity in thinking and reasoning
- (Communication)
  Students will learn how to:
  - improve their skills in a writing an academic paper
  - make academic presentations
  - evaluate different forms of (risk) communication
- (Lifelong learning skills)
  Students will:
  - be ready to evaluate and take decisions under conditions of uncertainty
  - be better prepared to their future professional life in a socially responsible way
  - be able to propose innovation solutions to complex and uncertain problems

Topics Covered

The course will cover different topics both from a theoretical and a more practical point of view.

The list of topics includes:

- Scientific reasoning: deduction, induction, and abduction
- Elements of logic and argumentation
- Probabilistic reasoning: biases and paradoxes
- Risk theory
- Risk perception
- Risk communication
- Risk and moral argumentation
- Decision making under severe uncertainty
- Technological innovation and uncertainty
- Scenario planning
- Sustainability and scientific values

Bibliography

Main textbooks

Damiano Canale, Roberto Ciuni, Aldo Frigerio, Giovanni Tuzet, Critical Thinking. An Introduction, Editore: Bocconi University Press - Egea, Anno edition: 2021, ISBN: 9788899902858

052557 Data Intelligence Applications
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Having attended:
- A course on Machine Learning is suggested, but not strictly necessary,
- A course on Economics and Computation is suggested, but not strictly necessary.

Learning Objectives

The goal of the course is to provide advanced skills in machine learning and optimization for challenging real-world data-science applications. More precisely, the course explores mathematical models, optimization algorithms, and machine learning tools. In particular, the course focuses on 4 main real-world applications in which computational data science is crucial: pricing in e-commerce, digital advertising, social networks, matching. For every real-world application, the goals of the course are: providing a description of the real-world scenario (in collaboration with a company working in that field) and of the computational problems, providing mathematical models representing the scenario, providing optimization models, providing machine learning tools to deal with uncertainty. The treatment of the topics will be both from a theoretical point of view, describing the models/algorithms and their properties, and from a practical point of view, discussing how the algorithms can be applied and applying them in practice during some laboratory sessions.

Expected Learning Outcomes

Students are expected to learn:
- how to model real-world applications by means of mathematical models from microeconomics,
- how to identify the most suitable class of algorithms to solve a given problem,
- how to use the tools already available to solve a given problem in practice,
- how to design an algorithm to solve a given problem whenever no algorithm is known.

Topics Covered

1. Pricing in e-commerce

1.1. *Introduction to pricing*

1.1.1. Scenarios

1.2. *Pricing a single product with infinite inventory*

1.2.1. Optimization model

1.2.2. Learning the demand curve

1.2.3. Unimodal bandit

1.2.4. Facing non-stationary pricing problems

1.3. *Pricing a single product with finite inventory*

1.3.1. Optimization model

1.3.2. Algorithms and regret

1.4. *Laboratory*

1.4.1. Implementing an algorithm to learn the demand curve
1.4.2. Implementing an algorithm to learn unimodal demand curve
1.4.3. Implementing an algorithm to learn a non-stationary demand curve

2. Digital advertising

2.1. *Introduction to digital advertising*
2.1.1. Funnel and general tools (Analytics, DoubleClick)
2.1.2. Search advertising: players, formats, auctions, available tools (AdWords)
2.1.3. Social advertising: players, formats, auctions, available tools (Facebook)
2.1.4. Display advertising: players, formats, auctions, available tools

2.2. *Pay-per-click optimization*
2.2.1. Optimization model
2.2.2. Bid-budget optimization algorithms without uncertainty
2.2.3. Learning bid-budget optimization algorithms (combinatorial bandits)
2.2.4. Target segmentation

2.3. *Other issues*
2.3.1. Funnel based channel interdependency
2.3.2. Publisher-side problems

2.4. *Laboratory*
2.4.1. Implementing a click-bid curve regression algorithm
2.4.2. Implementing a budget optimization algorithm
2.4.3. Implementing a target segmentation algorithm

3. Social influence

3.1. *Introduction to social influence*
3.1.1 Markets with network externalities
3.1.2. Small world
3.1.3. From local to global

3.2. *Population cascade models*
3.2.1. Informational effects
3.2.2. Hard-threshold models
3.2.3. Soft-threshold models
3.2.4. Epidemics

3.3. *Influence* maximisation *algorithms*
3.3.1. Maximisation in hard-threshold model
3.3.2. Maximisation in soft-threshold model

3.4. *Learning the network*
3.4.1. Learning the graph structure (combinatorial bandits)
3.4.2. Regret analysis

3.5. *Laboratory*
3.5.1. Implementing an algorithm for spreading influence on a network

4. Matching

4.1. *Introduction to matching*
4.1.1. Scenarios

4.2. *Matching problems*
4.2.1. Basic matching problems: assignment problem and Hungarian algorithm
4.2.2. Cardinality constraints
4.2.3. Hopcroft-Karp algorithm Edmonds algorithm
4.2.4. 3-dimensional matching

4.3. *Stochastic optimization for matching*
4.3.1. Kidney exchange

4.4. *Learning and matching*

4.4.1. Matching while learning

4.5. *Laboratory*

4.5.1. Implementing some matching algorithms

Bibliography

Recommended materials

David Easley and Jon Kleinberg, Networks, Crowds, and Markets: Reasoning About a Highly Connected World, Editore: Cambridge University Press

057289 Data-Driven Modelling of Dynamical Systems and Optimal Control

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Basic knowledge of dynamical systems and control (e.g., those presented in the "Fondamenti di Automatica" course of the BSc. in Management Engineering).

Learning Objectives

The course aims at providing students of the Management Engineering M.Sc. program with methods and tools for modelling dynamical systems in the different forms useful for control design and dynamic decision making. To do this, students will be shown how these models can be employed as a basis to design predictors of future system states and outputs that may offer forecasting capabilities. Then, the identified models will be used in closed-loop with optimal controllers with the aim of modelling different decision-making and planning processes that may occur in the domains of interest and explore their performance over a finite and infinite time horizon.

Many practical examples of interest from different economical/production/management contexts will be employed to prove their impact in the application domains of interest for the students.

The course includes:

- Lecture sessions: they aim at illustrating, sharing and discussing models, conceptual frameworks, tools and empirical evidence and show, with numerical examples, how to master the presented tools;
- Computer labs: to practice the methods with hands-on experiences using the MATLAB/Simulink environment;
- Final project: to be carried out in small teams (3 students at most), and aimed to practically experiment the learnt concept in an application-oriented framework chosen among those of interest for the group.

Expected Learning Outcomes

At the end of the course, students are expected to:

- be able to build dynamical models from input/output data, both with time and frequency domain representations making use of appropriate model-identification methods;
- be able to design predictors for both input/output models and state-space ones;
- be able to setup an optimal control problem to model dynamic decision-making processes, and apply them to examples taken from real applications.

Topics Covered

- From data to models: Data-based identification and estimation problems (examples from various application domains). Model representations of dynamical systems in time and frequency domains. Models for classification, prediction, control and simulation. Main issues related to data-processing techniques for dynamical systems modelling.
- Model Identification: Input/output black-box identification: The Prediction Error Minimization (PEM) paradigm. Identification of I/O models via LS (Least Squares) and ML (Maximum likelihood) methods. Spectral estimation and transfer-function parameterization of the frequency response. A simple approach to state-space identification.
- State/Output prediction: Prediction methods from I/O models (Kolmogorov-Wiener theory). State estimation of a dynamical systems: Kalman filtering, prediction and regularization. One-step ahead predictors and multi-step prediction. Convergence and stability properties of the predictor. Comparison with I/O prediction. Use of the Kalman filter for the estimation of uncertain parameters. Overview of the use of prediction methods in control systems.
- Optimal control of Linear and Time Invariant (LTI) dynamical systems: Optimality criterion. Linear-quadratic control over finite and infinite time horizon. LQ cost function: multi-objective interpretation. Steady-state LQR control. Hints to LQG control. Examples of optimal control problems in the context of economical and production systems.

Bibliography

Recommended materials

Sergio Bittanti, Model Identification and Data Analysis, Editore: Wiley & sons, Anno edition: 2019

(Note: This book covers all the course program except for the Optimal Control part. It has a lot of additional material that will not be covered in the course. The book is available to students among the online resources of the Politecnico di Milano)

Lalo Magni, Riccardo Scattolini, Advanced and Multivariable Control, Editore: Pitagora Editrice, Anno edition: 2014

(This book covers many topics, the one of interest for this course is Optimal Control)

097314 De-Manufacturing
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
- Develop new ideas and solutions in business and industrial scenarios evolving over time

Expected Learning Outcomes

- Understand: The students will learn the key definitions of circular economy business processes, the underlying motivations, and the boundary conditions affecting the success of this business solution. Moreover, they will learn the key role of advanced de- and remanufacturing systems in view of the development of circular economy business models. Several real-life examples will be discussed in order to support the in-depth understanding of business practices.
- Design: The students will learn scientific and engineering methods in support of an efficient design and management of advanced de-manufacturing and remanufacturing systems.
- Develop: The students will learn the most relevant circular economy problems of the future and will be challenged with the analysis of future technology and business innovations to support these emerging needs.

Topics Covered

The economical and environmentally sustainable treatment of end-of-life products and industrial waste by de-manufacturing processes is the core topic of this course. De-manufacturing includes the set of technologies, tools and knowledge-based methods to remanufacture and re-use functions and to recover materials from industrial waste and post-consumer high-tech products, under a circular economy perspective. This course provides competences related to mechanical de-manufacturing processes and systems, with the objective to design and operate these technologies in environmental and economical sustainable way, in different industrial settings.

The course will be structured to cover the following topics:

- De-manufacturing paradigm: definition of de-manufacturing systems and examples of industrial applications; de-manufacturing performance measures; integrated process and system view of the problem.
- De-manufacturing technologies: description of mechanical de-manufacturing processes, including disassembly, re-manufacturing and recycling technologies; mechanical size-reduction and separation processes; the role of statistical and mechanical models in the design of de-manufacturing processes; advanced de-manufacturing technologies based on automated optical systems.
- De-manufacturing systems: features of de-manufacturing systems; material mixtures and granular flow models; multi-stage de-manufacturing systems modeling; performance evaluation and design of de-manufacturing systems; flexibility in de-manufacturing systems.

The students will carry out laboratory activities to develop hands-on knowledge on specific processes and process-chains.

Detailed Lectures Plan (32h)

Introduction (6h)

- De-manufacturing paradigm: definitions and context.
- Integrated view of disassembly, remanufacturing, recycling, and recovery.
- Overview of de-manufacturing processes and systems.
- Examples:
    - Remanufacturing of mechatronic components in the automotive industry: Electronic Control Units (ECUs), starters, alternators, engines.
    - Recycling systems for End of Life Vehicles: workflow and ASR (Automotive Shredding Residue) problem.
    - Recycling systems for WEEE: focus on Printed Circuit Boards (PCBs).
    - Recovery of key-metals by metallurgical processes from Lamps, hard drives, and PCBs.
- Performance Measures: grade/recovery trade-off.
- Integrated process and system view of the problem.

De-manufacturing processes and technologies (13h)

- Mechanical disassembly and remanufacturing processes. Disassembly graphs and disassembly planning.
- Mechanical recycling processes: size-reduction and separation.
- Mechanical size-reduction processes:
    - Overview of the cutting mechanisms;
    - Population Based Models for size reduction processes;
    - Experimental analysis.
    - Application and analysis of the results.
- Mechanical Separation processes:
    - Separation principles, physics and mechanisms;
    - Overview of technologies: eddy current separation, electrostatic separation, magnetic separation, floatation, sieving, jigging, separation by air, optical sorting technologies (NIR, VIS, SWIR). Comparison of technologies and criteria for the selection of the most suitable process/technology.

    - Modeling and simulation of separation processes;
    - Analysis of the output and use of the models for process parameters optimization.
- Thermal and chemical processes: characteristics and requirements on the upstream processes.

De-manufacturing systems (13h):

- De-manufacturing systems architectures and material transportation technologies.
- Modeling material mixtures and granular flows.
- Performance Evaluation of de-manufacturing systems:
    - Mass Balance Equations;
    - Analytical modeling of de-manufacturing systems dynamics.
- Design of de-manufacturing systems;
- Flexibility and modularity in de-manufacturing systems.

Detailed Class works and Labs Plan (21h)

De-manufacturing process planning (4h):

- Lab: given a set of electronic and mechatronic products, the student will analyse their structure, their materials, their joints and will decide upon the best possible de-manufacturing process sequence.
- Exercises: calculation of performance measures.

De-manufacturing processes and technologies (9h):

- Exercises: disassembly and remanufacturing.
- Exercises: selection of the best mechanical recycling process-chain, given mixture properties and material value.
- Exercises: use of the size reduction simulation model for process parameters' selection.
- Exercise: use of the separation models for the analysis of the recovery and grade in different operating conditions.
- Lab: visit to the ITIA-CNR De-manufacturing plant. Experimental activities at process level.

De-manufacturing systems (8h):

- Exercises: material flow and particle characterization and modeling.
- Exercises: analytical modeling of de-manufacturing system.
- Exercises: reconfiguration of recycling systems; impact of different flow control logics.
- Lab: visit to the ITIA-CNR De-manufacturing plant. Experimental activities at system level.

Bibliography

No texts suggested.

056982 Design of Experiments and Data Analysis
(8 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

It is absolutely mandatory to have a prerequisite of a 5 credits course on basic statistics. The statistics topics that must be known are:

- Statistical distributions: gaussian, t-student, chi-square, Fisher distribution.
- Confidence Interval and Tests: general framework of Confidence Intervals, general framework of standard tests with two hypotheses (H0 and H1), p-value concept, test about one or two means, tests about one or two variances (difference and ratio)
- Test to assess normality.

A review of these topics is in chapter 2 of the reference text.

Learning Objectives

The goal of the course is to enable students to design experiments and analyse their results using a State-of-the-Art Software (MINITAB).

Expected Learning Outcomes

Lectures will provide the basis for originality in applying ideas, sometimes in a research context in the Design and Analysis of Experiments field. Classwork in computer room will develop the student problem solving abilities in an unfamiliar environment. Some problems will be proposed and the students will be required to solve them under a light guidance of a tutor.

Topics Covered

1. Introduction to Designed Experiments Chpt 1)
2. Analysis of Variance (Chpt 3)
3. Experiments with Blocking Factors (Chpt 4)
4. Factorial Experiments (Chpt 5)
5. Two-Level Factorial Designs (Chpt 6)
6. Blocking and confounding Systems for Two-Level Factorials (Chpt 7)
7. Two-Level Fractional Factorial Designs (Chpt 8)
8. Linear Regression models (Chpt 10)
9. Response Surface Methodology (Chpt 11)
10. Robust Design (Chpt 12)
11. Random Effect Models (Chpt 13)
12. Other Topics (Chpt 15, paragraphs 15.1, 15.2)

Bibliography

Main textbooks

Douglas C. Montgomery, Design and analysis of Experiments, Editore: John Wiley & Sons, Inc., Anno edition: 2013, ISBN: 978-1-118-09793-9

Professor's Notes: https://beep.metid.polimi.it/web/3590427/attivita-online-e-avvisi#p

057028 Design Thinking for Business

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

The course actively engages students in an experiential learning process: in addition to conceptual inputs, the faculty will use case study discussion, workshop, teamworking sessions and team presentations. For this reason, it requires that participants:

- Attend class regularly and contribute to class discussions;
- Be fully prepared for class (by accomplishing the pre-assigned tasks);
- Actively participate in team projects and activities outside of class, and contribute to team learning.

The main educational process is thought for students who will actively participate in class and who will engage in team-bases activities. The course allows some students, who are not able to provide this form of active participation, an alternative educational process.

Attending students

The course is based on both individual and team activities. The lectures manly aim at illustrating and sharing frameworks, models and tools. In order to facilitate the understanding, case studies are presented and discussed along the lectures. During the course, participants develop the Team Design Thinking Project adopting the Design Thinking approach to face the brief proposed by the industrial partner. Participants are engaged in creating the teams through the Design Thinking process proposed by the Faculty. The teams are averagely composed by 6-8 members. The Team Design Thinking Project is based on three main phases:

- Envision: the first phase is based on desk analysis autonomously developed by each team and supported by the Faculty who facilitates the Envisioning Factory (design workshop aimed at envisioning the new meaningful direction and based on three dedicated sessions);
- Re-Interpret: the second phase is based on two interviews autonomously developed by each team (interviews aimed at enriching the new meaningful direction);
- Probing: the third phase is supported by the Faculty who facilitates the Probing Factory (design workshop aimed at probing the new meaningful direction and based on two dedicated sessions).

The Individual Written Exam, scheduled at the beginning of the off-term period (1st call), is composed by small case studies to be critically discussed, closed and open questions.

Not-attending students

Not-attending students are those who — for some major constraints [e.g. Interns, Erasmus, etc.] that should be clearly explained to the faculty by email — are not able to participate to more than 50% of classes and/or team activities. Students with overlapping classes should commit in participating to Design Thinking for Business activities within the abovementioned limit or follow the course as not-attending students.

The exam is oral and scheduled in the off-lectures period. Not-attending students will not be included in teams and have to develop the Individual Design Thinking Project: this activity substitutes the Team Design Thinking Project that attending students accomplish in teams. The Individual Design Thinking Project is about the same brief proposed to the teams along the course. Individual Design Thinking Projects are presented during the oral exam. Not-attending students have to send one week before the oral exam (silvia.magnanini@polimi.it) the Presentation.

The Faculty strongly suggest to attend classes and to engage in team activities. An active participation to the course not only improves the effectiveness of the learning process, but also reduces the overall effort that the student has to put in the preparation of the final exam characterising the course.

Learning Objectives

- Identify future trends, technologies and key methodologies in a specific domain;
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment.

Expected Learning Outcomes

- Identify future trends, technologies and key methodologies in a specific domain;
    - Understand and exploit technological and socio-cultural trends, explicit and latent user needs, together with a capability to interpret competitive dynamics in industries [Individual Written Exam];
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment:
    - Generate and develop new meaningful directions based on a deep understanding of the future dynamics of competition, society and technology [Team Design Thinking Project].

Topics Covered

Practitioners and scholars acknowledge the central role of design as a driver of innovation and change. What has driven the steep growth of attention to design in the latest years in the business community is a change of perspective: design is not only an aesthetic driver of innovation but as a whole innovation management practice, a new set of processes, mindsets, capabilities, and organizational settings.
It is something practiced not only by designers but by everyone in organizations who seeks to innovate. Design Thinking, in particular, is making the headlines, with an extremely rapid diffusion in the interest and practice of organizations. The increasing attention of practitioners to Design Thinking is evident by looking at the recent moves of large consulting organizations and tech corporations. Design Thinking is booming in those industries where the digital transformation requires new competences and capabilities for developing effective customer experiences. Also, software developers and integrators have extensively adopted Design Thinking practices.
We live in a world where technological opportunities are cascading on society at an unprecedented speed, a world awash with technologies and information. But humans do not use technologies or data; they need products and services, and design can allow people to navigate an overcrowded world. Far from being connected with the "form" of products, Design

Thinking is accepted as a formal approach to foster innovation. It looks at value and change from the perspective of people; or, even better, from the perspective of what is meaningful to people.
Similarly, to many other approaches, also Design Thinking combines three factors: a) technologies, how things are made and their performance improved; b) people, how these things are valuable for customers; c) business, how organizations can profit from offering them. The perspective embedded in Design Thinking makes it unique: Design Thinking starts from people. Design Thinking for Business course aims at enriching the capabilities to envision innovative scenarios and to lead transformations.
The approach embedded in Design Thinking is human-centered, abductive, iterative and intrinsically oriented to change and to envision new possibilities. An increasing number of firms in fact have recognized the importance of Design Thinking as a mean to achieve sustainable competitive advantage.

Bibliography

Recommended materials

Brown T, Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, Editore: Harper Collins Publishers, Anno edition: 2009

Kelley T, and Kelley D, Creative Confidence. Unleashing the creative potential within us all, Editore: New York: Crown Business, Anno edition: 2013

Knapp J, Zeratsky J, and Kowitz B, Sprint: How to solve big problems and test new ideas in just five days, Editore: Simon and Schuster, Anno edition: 2016

Martin RL, The design of business: Why design thinking is the next competitive advantage, Editore: Boston: Harvard Business Press, Anno edition: 2009

Verganti R, Design Driven Innovation: Changing the Rules of Competition by Radically Innovating What Things Mean, Editore: Harvard Business Press, Anno edition: 2009

Verganti R, Overcrowded - Designing Meaningful Products in a World Awash with Ideas, Editore: MIT Press, Anno edition: 2017

Beckman SL, and Barry M, Innovation as a learning process: Embedding design thinking, Editore: California Management Review, Anno edition: 2007

Beckman SL, To Frame or Reframe: Where Might Design Thinking Research go Next?, Editore: California Management Review, Anno edition: 2020

Brown T, Design thinking, Editore: Harvard Business Review, Anno edition: 2008

Buchanan R, Wicked problems in design thinking, Editore: Design Issues, Anno edition: 1992

Carlgren L, Rauth I, and Elmquist M, Framing design thinking: The concept in idea and enactment, Editore: Creativity and Innovation Management, Anno edition: 2016

Dell'Era C, Cautela C, Magistretti S, Verganti R, and Zurlo F, Four Kinds of Design Thinking: From Ideating to Making, Engaging, and Criticizing, Editore: Creativity and Innovation Management, Anno edition: 2020

Dorst K, The core of 'design thinking' and its application, Editore: Design Studies, Anno edition: 2011

Dorst K, and Cross N, Creativity in the design process: Co-evolution of problem-solution, Editore: Design Studies, Anno edition: 2001

Elsbach KD and Stigliani I, Design thinking and organizational culture: A review and framework for future research, Editore: Journal of Management, Anno edition: 2018

Kolko J, Abductive thinking and sensemaking: The drivers of design synthesis, Editore: Design Issues, Anno edition: 2010

Kolko J, Design thinking comes of age, Editore: Harvard Business Review, Anno edition: 2015

Liedtka J, Perspective: Linking design thinking with innovation outcomes through cognitive bias reduction, Editore: Journal of Product Innovation Management, Anno edition: 2015

Liedtka J, Why Design Thinking Works, Editore: Harvard Business Review, Anno edition: 2018

Liedtka J, Putting technology in its place: Design thinking's social technology at work, Editore: California Management Review, Anno edition: 2020

Magistretti S, Dell'Era C, Verganti R, and Bianchi M, The contribution of Design Thinking to the R of R&D in technological innovation, Editore: R&D Management, Anno edition: 2021

Magistretti S, Ardito L, and Messeni Petruzzelli A, Framing the Micro foundations of Design Thinking as a Dynamic Capability for Innovation: Reconciling Theory and Practice, Editore: Journal of Product Innovation Management, Anno edition: 2021

Micheli P, Perks H, and Beverland MB, Elevating Design in the Organization, Editore: Journal of Product Innovation Management, Anno edition: 2018

Micheli P, Wilner SJ, Bhatti SH, Mura M, and Beverland MB, Doing design thinking: Conceptual review, synthesis, and research agenda, Editore: Journal of Product Innovation Management, Anno edition: 2019

Seidel V, and Fixson S, Adopting design thinking in novice multidisciplinary teams: The application and limits of design methods and reflexive practices, Editore: Journal of Product Innovation Management, Anno edition: 2013

Verganti R, The Power of Criticism, Editore: Harvard Business Review, Anno edition: 2015

Verganti R, and Dell'Era C, Design-Driven Innovation: meaning as a source of innovation, Editore: in Dodgson M, Gann D, and Philips N (eds.), The Oxford Handbook of Innovation Management, Oxford University Press, Anno edition: 2014

Verganti R, and Norman D, Why Criticism Is Good for Creativity, Editore: Harvard Business Review, Anno edition: 2019

Zurlo F, and Cautela C, Design Strategies in Different Narrative Frames, Editore: Design Issues, Anno edition: 2014

097386 Development Economics
(8 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

The principles of development economics are key to understanding how we got to where we are, and why many development problems are so difficult to solve, and to the design of successful development policy and programs. The first goal of this course is to ensure that students understand real conditions and institutions across the developing world. The second is to help students develop analytic skills while broadening their perspectives of the wide scope of the field. The third is to provide students with the resources to draw independent conclusions as they confront development problems, their (sometimes) ambiguous evidence, and real-life development policy choice.

Expected Learning Outcomes

On successful completion of this course, students will be able to:

1. Demonstrate familiarity with some central themes and issues of economic development;
2. Demonstrate the understanding of the difference between growth and development, major growth theories, the measurement of inequality, significance of poverty, international trade, and role of foreign investments;
3. Discuss competing theories of economic development;
4. Analyse empirical evidence on the patterns of economic development.
5. Read critically the journal literature and draw independent conclusions as they confront development problems, their (sometimes) ambiguous evidence, and real-life development policy choice (also thanks to the 6-8 training sessions held in collaboration with UNCTAD).

On a voluntary base, students can also attend the Polimi MOOC "Entrepreneurship without borders" (and participate in the final UNCTAD competition).

Topics Covered

- **Introducing Global Development**

Traditional economic measures and the new economic view of development. The Millennium Development Goals.

Textbooks: Todaro M.P., Smith S.C. *Economic Development, 12th Edition.* Addison Wesley, ch.1-2
De Janvry A., Saudolet E. (2016). *Development Economics: Theory and Practice*. Routledge, ch. 1.
Readings: Sachs JD, Mellinger AD, Gallup JL. 2001. *The geography of poverty and wealth*. *Scientific American.* March; 284(3):70-5.

2. **Poverty, inequality and development**

Measuring inequality and poverty.

Textbook: Todaro M.P., Smith S.C. *Economic Development, 12th Edition.* Addison Wesley, ch. 5

Readings: Foster J., Seth S., Lokshin M., Sajaia Z. 2013. A unified approach to measuring poverty and inequality. Theory and practice. The World Bank.

3. **Classic Theories of Economic Growth and Development**

Development as growth and the linear stages theories. Structural change models. The international-dependence revolution, and the neoclassical counterrevolution.

Textbook: Todaro M.P., Smith S.C. *Economic Development, 12th Edition.* Addison Wesley, ch. 3

4. **Contemporary Models of Development and Underdevelopment**

Underdevelopment as a coordination failure. The Big-Push. Amartya Sen: The capability approach.

Textbook: Todaro M.P., Smith S.C. *Economic Development, 12th Edition.* Addison Wesley, ch. 4

Readings: Easterly W. 2006. Reliving the 1950s: the big push, poverty traps, and take-offs in economic development, *Journal of Economic Growth*, Volume 11, Issue 4, pp 289–318

5. **Institutions and development**

Textbook: De Janvry A., Saudolet E. (2016). *Development Economics: Theory and Practice*. Routledge, chapter 20.

Readings: Abramovitz, M. (1986). Catching Up, Forging Ahead, and Falling Behind. *Journal of Economic History*, 46:2, pp. 385-406.

Acemoglu D., Smith J. The role of institutions in growth and development, *Review of Economics and Institutions,* 2010, vol. 1, no. 2, pp. 1-33.

Acemoglu D., Johnson S., Robinson J. 2001. The colonial origins of Comparative Development: An Empirical Investigation, *American Economic Review*, Vol. 91, No. 5 (Dec., 2001), pp. 1369-1401.

6. **Changing landscapes: Key issues for achieving sustainable development [by 2030]** - in collaboration with UNCTAD (Dr. Fulvia Farinelli)

Laboratory [with individual and group exercises] on: 1. The role of the private sector in achieving the SDGs; 2. The emergence of new business models for sustainable development; 3. The importance of innovation and soft entrepreneurial skills to address the global development challenges; 4. Promoting sustainable efficiency; 5. Generating new business opportunities with social impact.

Readings: UN Global Compact (2015), Impact: Transforming Business, Changing the World, https://www.unglobalcompact.org/library/1331

Michael E. Porter and Mark R. Kramer (2011), "Creating Shared Value: How to reinvent capitalism—and unleash a wave of innovation and growth", *Harvard Business Review*
http://www.nuovavista.com/SharedValuePorterHarvardBusinessReview.PDF

Ingrid Burkett Knode (2017), Using the Business Model Canvas for social enterprise design
http://cscuk.dfid.gov.uk/wp-content/uploads/2016/07/BMC-for-Social-Enterprise.pdf

7. **International Trade Theory and Development Strategy**

Traditional trade strategies for development: Export promotion vs. import substitution. South-south trade and economic integration

Textbook: Todaro M.P., Smith S.C. *Economic Development, 12th Edition.* Addison Wesley, chapter 12

Readings: Harrison A. 1996. Openness and growth: A time-series, cross-country analysis for developing countries, *Journal of development Economics* 48 (2), 419-447

Hanson GH, Harrison A. 1999. Trade liberalization and wage inequality in Mexico, ILR Review 52 (2), 271-288.

8. Multinational Enterprises, Global Value Chains, and local development.

Textbook: Todaro M.P., Smith S.C. *Economic Development, 12th Edition.* Addison Wesley, chapter 14
Readings: *Aitken* B.J., *Harrison* A.E. *1999*. "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela," *American Economic Review*, vol. 89(3), pages 605-618.
Haddad M, Harrison A. 1993. Are there positive spill overs from direct foreign investment? Evidence from panel data for Morocco, *Journal of development economics*, 42 (1), 51-74.
Eskeland GS, Harrison AE. 2003. Moving to greener pastures? Multinationals and the pollution haven hypothesis, *Journal of development economics*, 70 (1), 1-23.

9. Impact evaluation of development policies and programs

Textbook: De Janvry A., Saudolet E. (2016). *Development Economics: Theory and Practice*. Routledge, ch. 4.
Readings: Galiani S., Gertler P., Schargrodsky E. (2005), Water for life: The impact of the privatization of water services on child mortality, *Journal of Political Economy* 113(1): 83-120.
Guidolin M., La Ferrara E. 2007, Diamonds are forever, wars are not: is conflict bad for private firms? *American Economic Review*, 97(5): 1978-93.

Bibliography

See the references to each subject in the dedicated field

057065 Digital Business LAB
(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

Digital Business is the transformation of a company business generated by the Information and Communication Technology (ICT) and, more in general, by Digital Innovation. It can involve the internal processes, (e.g. the supply chain management, market relationship management, etc.), people and organization (e.g. digital capabilities, digital and agile organization, HR transformation) but also the entire business model. Digital Business means also the transformation of entire industries and supply chains, the creation of new sectors (e.g. those of Apps, eCommerce, etc.) and of completely new companies (i.e. Start-ups). The objective of this course is twofold. First, it aims to provide the methodologies and tools to develop and assess Digital Innovation projects (in both existing and new companies/market). Second, it aims to create an arena in which students can apply the methodologies to real cases in different digital areas. Objectives:

- Understand context, functions, processes and performance (DdD1)
- Identify trends, technologies and key methodologies in a specific domain (DdD2)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment (DdD3)

Expected Learning Outcomes

Students will:

- Understand and interpret the strategic role of digital innovation, the current competitive digital business environment and its evolution;
- Learn and critically understand – form a strategic point of view - the most important "digital trends" affecting the business, the competitive environment and the industries, such as cloud, big data, Internet of Things, Artificial Intelligence, eSupply Chain, eProcurement, digital marketing etc;
- Know the main steps and methodologies to be exploited when launching a digital business (start-up). In this light, a specific emphasis will be given on the following methodologies: lean start up approach, business planning, etc;
- Know the main steps and methodologies to be exploited when supporting and innovating an existing business leveraging on digital innovation.

Students will:

- Identify and apply the appropriate tools and methodologies for digital business innovation;

- Discern and select the appropriate strategic approaches and technology trends related to a digital business;
- Identify the appropriate strategic methodologies and tools to launch a new digital business or renew an existing traditional business.

Students will:

- Integrate knowledge on digital innovation and technologies with business strategy and processes;
- Manage the complexity of making judgements on digital business innovation and related social impact with limited information available;
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment;
- Develop new ideas and solutions in business and industrial scenarios evolving over time.

Topics Covered

Strategic analysis applied to digital business. SWOT analysis, Value Chain, competitive advantage and competitive forces, strategic innovation and creativity (e.g. resource-based view and blue ocean strategy), business model design, digital disruption.

Models, methodologies and tools enabling the launch of a new business and to compete in high tech contexts. Business model design through the business model canvas, the lean start-up approach, the start-up financing, resource gathering and allocation.

Digital-Driven analysis and Business Process reengineering. Methodologies, techniques, and tools to analyse and re-design processes, when launching digital projects in existing companies

Value Assessment models. How to develop a model to assess the value and impacts generated by Digital Innovation projects. Application of the methodology to real examples and case studies.

Digital Markets & New Business Models. A deep dive into the most important digital trends enabling the development of new markets. Digital Commerce, Mobile Content & Apps, Digital Payments, Mobile Enterprise, Social Networks, Cloud and ICT-as-a-service, Big Data, Internet of Things, Artificial Intelligence, etc.

Digital marketing. Advanced market research (how to use big data and data tracking to better understand the customer behavior), Customer experience design (methodologies and tools to design multichannel customer experiences), Tool supporting marketing planning (methodologies and techniques to target customers and to develop customized marketing plans), KPI of a multichannel marketing plan (tools and techniques supporting customer accountability, development of scorecards to measure a multichannel marketing plan).

Digital Operations. eSupply Chain (automation and integration of the supply chain operative processes, e.g. logistics, sales, administration, etc.), Supply Chain Collaborative Planning (integrated and collaborative supply chain management, e.g. co-design, collaborative planning, etc.), Supply Chain Visibility (Internet of Things, tracing and visibility along the supply chain, anti-counterfeiting).

People and Organization. Digital capabilities assessment and strategy, digital and agile organization, smart working and new ways of working, employer branding, HR process transformation

Bibliography

Main textbooks

Ries E., The lean start-up: How today's entrepreneurs use continuous innovation to create radically successful businesses, Editore: Crown Books, Anno edition: 2011

Downes, L & Nunes, P., Big bang disruption, Anno edition: 2013

056993 Digital Business

(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

Digital Business is the transformation of a company business generated by the Information and Communication Technology (ICT) and, more in general, by Digital Innovation. It can involve the internal processes, (e.g. the supply chain management, market relationship management, etc.), people and organization (e.g. digital capabilities, digital and agile organization, HR transformation) but also the entire business model. Digital Business means also the transformation of entire industries and supply chains, the creation of new sectors (e.g. those of Apps, eCommerce, etc.) and of completely new companies (i.e. Startups). The objective of this course is twofold. First, it aims to provide the methodologies and tools to develop and assess Digital Innovation projects (in both existing and new companies/market). Second, it aims to create an arena in which students can apply the methodologies to real cases in different digital areas.

Objectives:

a) Understand context, functions, processes and performance

b) Identify trends, technologies and key methodologies in a specific domain

Expected Learning Outcomes

Students will: 1) Understand and interpret the strategic role of digital innovation, the current competitive digital business environment and its evolution; 2) Learn and critically understand – form a strategic point of view - the most important "digital trends" affecting the business, the competitive environment and the industries, such as cloud, big data, Internet of Things, Artificial Intelligence, eSupply Chain, eProcurement, digital marketing etc; 3) Know the main steps and methodologies to be exploited when launching a digital business (startup) or renewing a traditional business. In this light, a specific emphasis will be given on the following methodologies: lean start up approach, business planning, business process reengineering, investment evaluation, etc; 4) Know the main steps and methodologies to be exploited when supporting and innovating an existing business leveraging on digital innovation.

Students will also: 1) Identify and apply the appropriate tools and methodologies for digital business innovation; 2) Discern and select the appropriate strategic approaches and technology trends related to a digital business; 3) Identify the appropriate strategic methodologies and tools to launch a new digital business or renew an existing traditional business.

Topics Covered

Strategic analysis applied to digital business. SWOT analysis, Value Chain, competitive advantage and competitive forces, strategic innovation and creativity (e.g. resource-based view and blue ocean strategy), business model design, digital disruption

Models, methodologies and tools enabling the launch of a new business and to compete in high tech contexts. Business model design through the business model canvas, the lean start-up approach, the start-up financing, resource gathering and allocation.

Digital-Driven analysis and Business Process reengineering. Methodologies, techniques, and tools to analyse and re-design processes, when launching digital projects in existing companies

Value Assessment models. How to develop a model to assess the value and impacts generated by Digital Innovation projects. Application of the methodology to real examples and case studies.

Digital Markets & New Business Models. A deep dive into the most important digital trends enabling the development of new markets. Digital Commerce, Mobile Content & Apps, Digital Payments, Mobile Enterprise, Social Networks, Cloud and ICT-as-a-service, Big Data, Internet of Things, Artificial Intelligence, etc.

Digital marketing. Advanced market research (how to use big data and data tracking to better understand the customer behaviour), Customer experience design (methodologies and tools to design multichannel customer experiences), Tool supporting marketing planning (methodologies and techniques to target customers and to develop customized marketing plans), KPI of a multichannel marketing plan (tools and techniques supporting customer accountability, development of scorecards to measure a multichannel marketing plan).

Digital Operations. eSupply Chain (automation and integration of the supply chain operative processes, e.g. logistics, sales, administration, etc.), Supply Chain Collaborative Planning (integrated and collaborative supply chain management, e.g. co-design, collaborative planning, etc.), Supply Chain Visibility (Internet of Things, tracing and visibility along the supply chain, anti-counterfeiting).

People and Organization. Digital capabilities assessment and strategy, digital and agile organization, smart working and new ways of working, employer branding, HR process transformation.

Bibliography

Main textbooks

Ries, E. (2011). The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses. Crown Books.

Downes, L., & Nunes, P. (2013). Big bang disruption.

056954 Digital Factory
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep– Dec)

Prerequisites

The activities in the course will take advantage of digital tools to support the analysis of manufacturing system, to this aim a basic knowledge of the python programming language is advised. A basic knowledge in machine learning applied to image analysis is also advised. In case, elective seminars will be organized.

Learning Objectives

Digitizing the European Industry is aimed at drawing the full benefits from digital technologies in manufacturing. In real manufacturing environments, aligning management and control approaches to the current state of the system and managing the occurrence of unforeseen events are key factors.
The interaction between humans and digital technologies is a valuable tool to master these situations.
The objective of the course is to provide knowledge and skills in digital models of manufacturing systems taking into consideration the presence of human workers. These models support the management and control of complex manufacturing systems coping with variability and uncertainty.

Expected Learning Outcomes

The main expected learning outcomes of the course, achievable through a mix of activities aimed at providing the students the possibility to learn and experiment digital tools for manufacturing and use them within realistic industrial problems. In particular, the course will allow students to achieve knowledge and comprehension in order to:

- Model a manufacturing environment in terms of its Digital Twin, understand the relevant elements and influencing factors, defining proper modelling hypothesis, collecting and structuring information and data;
- Select and apply digital tools and technologies to analyse and solve realistic industrial cases;
- Work and cooperate in a group addressing the complexity of manufacturing problems as well the integration of different digital tools.

Topics Covered

1. Digital models for manufacturing systems (Digital Twin).
   - Digital models for the representation of factory objects (resources, processes and products) based on standards and ontologies for manufacturing.
   - Digital Twin models for manufacturing systems.
   - VR/AR models for manufacturing systems.
   - UML State charts for the modelling of the control of manufacturing systems.
2. Human modelling and monitoring in operating environments

- AI-based image analysis approaches for human pose estimation and object recognition.
- Modelling of manual-executed processes (discrete sequences of operations).
- Activity recognition for error identification and monitoring of human-executed activities (es. assembly processes).

3. Management and control approaches based on Digital Twin models
   - In-situ evaluation approaches for short-term scheduling decisions.
   - Robust planning approaches applied to proactive-reactive scheduling and sequencing policies.

Bibliography

No texts suggested.

056949 Digital Manufacturing

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep– Dec)

Prerequisites

The prerequisites know-how deals with the following topics: design of manufacturing systems; information systems; operations management.

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

The main expected learning outcomes for each of the following capabilities are:

- Understand: the students will learn how the automation and digital technologies (i.e. Industry 4.0) are affecting the future manufacturing systems, both in the process industry as well as in the discrete manufacturing systems;
- Identify: the students will learn how to select (i.e. identify) the best technology and the best application scenario;
- Design: designing a manufacturing system is a complex process which requires to deal with the hard, soft and organizational dimensions of the design of the system. Quantitative and qualitative techniques will be explained. The impact evaluation will also be assessed in order to give students the know-how on how to understand the impact of their decisions.

Topics Covered

Part I – Introduction

1. **Advanced and Sustainable Manufacturing Strategies**
   1.1 Sustainable Development (social, environmental and economic megatrends
   1.2 The importance of Manufacturing in the regional, national and global economy
   1.3 Manufacturing as key enabler of the Europe’s societal challenges

Part II – Competitive Advanced Manufacturing

2. **Advanced Manufacturing: Automation in the Process industry**
   2.1. Control
   2.2. Typologies of control architecture (monitoring, direct digital control, supervisory control)

3. **Advanced Manufacturing: Automation in the Discrete Manufacturing industry**
   3.1. Design and management of Advanced Manufacturing Systems (AMS)
   3.2. Real time control systems. Loading and dispatching
   3.3. Soft computing techniques for the design and management of manufacturing systems
   3.4. Industrial robots

Part III – Sustainable Manufacturing

4. **BOL-Energy- and Resource-efficient Manufacturing**
   4.1. Green and Customer-focused Manufacturing
   4.1.1. Green Product Development
   4.1.2. Sustainable Mass customisation, Highly personalised production, Servitization in Manufacturing
   4.2. Factory life-cycle concepts. Integrated design, modeling and multi-level simulation of an Energy Efficient Factory (i.e. machine energy states, energy value-stream mapping, Technical Building Services and building facilities)
   4.3. Energy assessment: tools, audits, certification, KPIs,
   4.4. Best available technologies (BATs)
   4.5. Strategies for Energy optimisation along the whole value chain (i.e. factories clustering, Industrial symbiosis, new business models, etc.)
   4.6. Smart Manufacturing for Sustainability. ICT for Manufacturing

5. **BOL-Human-Centric and social sustainable manufacturing**
   5.1. Factory context and workers for human-centric workplaces. Skill and competence knowledge workers. Worker-centered and skill-oriented production planning and operation. Cognitive and symbiotic automation.
   5.2. Design and co-evolution of the factory in relationships with social context (stakeholders such as local communities, other factories, policy makers, and training centres)
   5.3. Assessment and practices of Social Sustainability

6. **End-of-Life Cycle Product Management**
   6.1. Strategies and Technologies for EOL in the different sector: Prevent, Re-use (re-manufacturing, dis-assembly, etc.), re-cycling, energy recovery, disposal
   6.2. Tools and assessment methodologies (regulatory, social, environmental and economic dimensions) for the identification of the best strategy/technology. Qualitative and quantitative Decision Support Systems for Design and Planning. Performance measurements
   6.3. Case studies in the automotive, aerospace, machine tools and electronics (including white goods) sectors
   6.4. European and Italian Regulations
   6.5. Product Life cycle knowledge for remanufacturing

6.6. Rare and critical material management (i.e. Urban mining)

Bibliography

No texts suggested.

055892 Digital Security Management
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep– Dec)

Prerequisites

Concepts of software engineering and architectures, databases and information systems, enterprise management, operations.

Learning Objectives

The course Digital Security Management addresses the fundamental management and technical aspects of security in enterprises, emphasizing the need for good security management practices. The basic goal of this course is to provide *concepts* and *practical methods* about the management of security policies, methods, tools, security services, and responsibilities in organizations. The knowledge that will be acquired can enable an aware communication between those who speak the language of security and those who are acquainted with the language of enterprise, so supporting informed conversations between *technology teams* and *organization managers*. More precisely, the course aims are to: i) identify the problems and concepts of security management in organizations; ii) show how these problems can be solved through organizational and technical measures. Therefore, it describes the policies, methods, tools, and resources to set in place in private and public organizations towards these aims.

Expected Learning Outcomes

The course is aligned with courses taught at the major International Universities (e.g., MIT, Sloan, University of London, Universities in North Europe), and in various Schools of Management and Technical Schools. The students will learn theory about security and privacy issues, and mainly practical experiences about tools to be displayed in enterprises and organizations to set in place security plans and monitor the security services. Through interventions and testimonial, security governance and monitoring will be explained, so that group work and cooperation on cases guide the students in developing their own security solutions to specific problems presented during classes.

Topics Covered

The course is organized in two parts: 1) an introduction to the "language" and fundamentals of security, and of security management in particular; 2) the description of technical measures that can be adopted to deploy security management. Security and privacy of data (and of "new data" such as Big Data, streaming data from IoT systems, Datawarehouse systems) is focused. The GDPR and its application are analysed through descriptions of guidelines to security plans formulation. Testimonials of security management will give cases and experiences in practical application of measures for data privacy, security plans, management of security services for privacy protection, and other security management practices in enterprises.

Bibliography

Main textbooks

Notes of classes, available along the classes. Edited by the teacher

Recommended materials

Susanto, H. and Almunawar, M.N., Information Security Management Systems: A Novel Framework and Software as a Tool for Compliance with Information Security Standard, Editore: Apple Academic Press, Anno edition: 2018

Peltier, T.R., Information Security Policies, Procedures, and Standards: guidelines for effective information security management, Editore: Auerbach Publications, Anno edition: 2016

Video: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-858-computer-systems-security-fall-2014/video-lectures/

Cybersecurity for Managers: A Playbook (online) 2020

Cyber DB books https://www.cyberdb.co/10-cybersecurity-books-2018/

Fugini et al., Database Security, Editore: Addison Wesley, Anno edition: 1995

097384 Digital Technology

(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Basic knowledge of fundamentals of programming.

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance:
    - Illustrate recent technological trends in data acquisition
    - Illustrate agile project management methods
    - Compare OLTP and OLAP
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
    - Illustrate the cloud computing paradigm
    - Give examples of use of RFID, sensors, mobile computing
    - Compare ethical and societal issues of digital technology
    - Criticize security threats and illustrate possible solutions
- Design IT systems using design frameworks and the ArchiMate modeling concepts.
- Understand Python code fragments performing data acquisition and processing.

Topics Covered

The course presents how to develop innovative IT projects and the elements for performing feasibility studies for information systems projects, focusing on their organizational and technological components, project management, and discussing the main choices to be performed. Case studies will be presented in the course. The course studies the following topics:

- Organizations, management and the networked enterprise, a preliminary analysis of Innovation Systems in present-day global systems and their role inside world-class organizations and small enterprises.

- Global eBusiness collaboration, the link between business processes and Information Systems and the central role of systems enabling collaboration in modern-day environments.
- Enterprise Architectures and architectural components in an Information System: Business, Organizational, Functional Architectures, Technological aspects. The Zachman framework. The ArchiMate notation to represent Enterprise Architectures.
- IT infrastructure and emerging technologies: service-based approaches (Iaas, PaaS, SaaS), cloud computing, mobile information systems, RFID and IoT.
- Ethical and social aspects of IS.
- IS security, privacy issues, and the risks connected to systems vulnerability and abuse. Principles of cryptography and digital signature. Blockchain technology. Introduction to GDPR.
- Foundations of Business Intelligence: databases and information management, data warehouses.
- Managing knowledge and how to exploit enterprise-wide data in all its forms, from structured information to unstructured and volatile data.
- Managing projects, best practices for project selection, management and exploitation, acquiring perception on Information Systems business value, change management and risk management.
- Introduction to the Python programming language: understanding data acquisition and processing. Classes, methods and functions, attributes, data types and their manipulation (string, list, dictionary), control structures, file handling.

Bibliography

Main textbooks

Laudon & Laudon, Management Information Systems - Managing the digital firm, Global edition, 16th ed., paperback edition o editions successive, Editore: Pearson, Anno edition: 2019

Course material will be made available on Beep during the course http://beep.metid.polimi.it

B. Pernici, Digital technology exercises, Editore: pdf on BeeP, Anno edition: 2020

Recommended materials

G. Wierda, Mastering ArchiMate Edition III, Anno edition: 2018

Paul Grefen, Beyond e-business - Towards networked structures, Editore: Routledge, Anno edition: 2016, ISBN: 9781315754697

057554 Digital Twin for Industrial Systems Management

(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Students must have acquired the following skills:

- Command of MATLAB working principles and basic scripting is appreciated;
- Basic knowledge of statistics for data analysis;
- Fundamentals of theoretical and applied mechanics, solid mechanics, electrical systems and industrial plants, as provided in the B.Sc. in Energy Engineering

If necessary, students will be provided with references and material to fill the gap.

Learning Objectives

The course is aimed at providing the students with practical concepts and instruments for modelling complex systems in their operative environment or asset, potentially simulating the entire life-cycle of an industrial system (including degradation phenomena) through its Digital-Twin. The course will merge the multidisciplinary inputs from energy, mechanical, electrical, control and management engineering in a unique and coherent virtual framework that can be used for design, operation and monitoring optimizations. The course will introduce students to the field of industrial system monitoring, specifically focusing on the role of models (and Digital-Twins) in the diagnosis and prognosis of industrial systems and components, exploiting statistical pattern recognition and machine learning to interpret changes in their measured features. The course will provide additional insight to the modelling of energy plant systems, with laboratory experiences focused on realistic application scenarios, also involving national and/or international industrial representatives.

Expected Learning Outcomes

By the end of the course, students will learn contents and practices according to what defined in the leaning objectives. In terms of acquired knowledge and understanding, students will be able to:

- Examine scenarios where Digital-Twin models can bring benefits
- Predict benefits and drawbacks of modelling methods in the framework of industrial system design, operation and monitoring optimization
- Interpret existing application studies in the literature and implement methodologies appropriate for solving complex problems, both systematically and creatively.

Concerning the ability to apply the acquired knowledge and understanding, students will be able to:

- Apply the methods covered during the course on realistic scenarios
- Demonstrate the pros and cons of the modelling strategy in relation to the application scenario
- Critically, independently and creatively solve problems with some originality in new or unfamiliar environments within the multidisciplinary context of Digital-Twins

Through a schedule of hands-on practices and laboratories, students will also acquire the skills to formulate a judgment, meaning to:

- Analyse the modelling framework
- Formulate subjective expectations on the results
- Judge the results as a comparison with prior expectations
- Provide a sound judgment even on the basis of incomplete or restricted information

Furthermore, through the group laboratories, students will gain the ability to autonomously take initiative to identify and address learning needs for further knowledge, leveraging on the multidisciplinary background of the group. Additionally, the students will improve their management and relational soft skills by working as a group of experts.

Finally, students will improve their communication skills, being able to communicate their conclusions and recommendations with the argumentation of the knowledge and rationale underpinning these, to both specialist and non-specialist audiences clearly and unambiguously.

Topics Covered

The course contents are delivered through lectures and hands-on computer laboratory practices with professors and/or a tutor. The course covers the following topics divided in modules as per the description below:

Module 1 – Introduction

- Topic 1.1 – Introduction and motivation for the rapid growth of Digital-Twins for industrial applications. Real case examples will be provided as input to the students, thus setting the motivation and goal of the course. Specific attention will be devoted to the application of Digital-Twins for system health management and maintenance optimization.
- Topic 1.2 – Design and maintenance criteria evolution (from safe life to damage tolerant design, from fault driven to predictive maintenance). Introduction of Health and Usage Monitoring Systems as a means toward process automatization.

Module 2 – Time based modelling

- Topic 2.1 – Time-based modelling: application of time-based simulation with MATLAB SIMULINK-SIMSCAPE. Hand-on practices on energy system simulation.
- Topic 2.2 – Time-based degradation and failure mechanisms: an overview of different degradation and failure mechanisms occurring on the most widely used components in the energy field of application is provided, including fatigue, creep, corrosion, pitting, lubricant degradation, battery State of Charge, including an overview of failure mechanisms. The students will particularly focus on the analytical and numerical modelling strategies for predicting damage progression.
- Topic 2.3 – Time-based modelling of system degradation: simulation is used to predict in a virtual environment the effect of a potential damage over the features of the system observed by a sensor.

Module 3 – Event based modelling

Topic 3.1 – Event-based modelling: Discrete Event Simulation (DES) with is introduced as a means to simulate systems depending on discrete time, with particular focus on event-based degradation modelling. Practical laboratories using MATLAB SimEvents (in combination to Simulink) will be provided, e.g. modelling scenarios typical of the operation research discipline.

Topic 3.2 – Decision logic modelling: concepts and instruments will be provided to simulate the decision logics in an operative framework. After a brief recall to state-machine concept, practical laboratories using MATLAB State-Flow will be provided, simulating realistic scenarios of industrial systems' management, e.g. the battery management system and the operation and monitoring of energy systems.

Module 4 – Surrogate modelling

Topic 4.1 – Surrogate modelling: for most application, the Digital-Twin should be fast enough to be run in real-time. This is not feasible with direct simulation, while surrogate models can be used for approximating input-output relations. Different methods based on Machine Learning (e.g. Artificial Neural Networks, Gaussian Processes, etc.) will be considered for the definition of surrogate models.

Module 5 – Model updating

Topic 5.1 – Basics of Monte-Carlo sampling: the concept of Monte-Carlo sampling will be recalled as a mean to implement repeated and efficient simulation of the Digital-Twin, featuring both random events and parameter variations based on Design of Experiments.

Topic 5.2 – Digital-Twin updating: The Digital-Twin must be updated during service life based on observations by sensors. Various methods for parameter identification and tracking based on Bayesian inference and Monte-Carlo sampling will be implemented in the framework of damage identification and operation optimization.

The theoretical aspects introduced in the course will be correlated with laboratories, for a direct implementation of the methods, e.g. including the implementation of a digital-twin for the Health and Usage Monitoring and Prognostic Health Management of an energy system:

- The students will apply the concepts developed during the course to a real-case study.
- Students will analyse the industrial system, modelling its components in their operative scenario, including potential degradation and failure mechanisms and the logistic support to guarantee their operability.
- Students will perform trade-off analysis to support management decisions
- Finally, the students will provide a report in the form of a presentation of their results, that will be evaluated as part of their final score.

Bibliography

Recommended materials

N. Khaled, B. Pattel, A. Siddiqui, Digital-twin development and deployment on the cloud

C.M. Bishop, Pattern recognition and machine learning

051509 Diritto dell'Energia ( )

(5 ECTS credits)

This course is offered in the:

Spring Semester (Feb – May)

Prerequisites

First level courses concerning Mathematical Analysis and Geometry.

Learning Objectives

The Energy Law course is aimed at providing students of the Master's Degree Courses in Energy Engineering (8 CFU) and Management Engineering 5 (CFU) with the basic tools necessary to understand the legal framework that regulates and conditions the energy market , in particular in light of European regulations, with particular reference to the structure of responsibilities, the content and purposes of independent regulation, as well as the administrative activity relating to energy planning, authorization for the construction and operation of plants and assessment of the respective impacts on the territory.

Expected Learning Outcomes

At the end of the course, the student is expected to have assimilated the basic notions regarding (i) principles of the constitutional and European system relevant to the energy market, (ii) structure of regulatory and administrative competences, (iii) purposes and tools of independent regulation, (iv) administrative procedures for the construction of plants, environmental assessments and regulation of the main incentive tools for the production of energy from renewable sources and energy efficiency.

Topics Covered

The legal norm is the starting and finishing point of a particularly complex interpretative path. Through in-depth reading of some regulations, students will be able to understand the main characteristics of the technique and legal reasoning, in order to be able to interpret the functioning and characteristics of a constantly evolving market from an unusual point of view.

A first part of a general introductory nature will be followed by a more specific study of legal regulation with particular reference to the energy sector, followed by an in-depth study of the relationship between energy and the environment, the analysis of some segments of the electricity supply chain, the related problems to renewable energy sources (RES), the study of case law and some focus on specific problems.

To support the lessons, slides, scientific writings, legislation and case law will be used.

A. General Part

- The concept of "legal rule" and its function. The notion of legal system and its sources
- The "energy" matter between public law and private law. Constitutional sources and principles. Structure of skills
- General notions regarding public intervention and economic regulation. The notions of "public service", "universal" and "network"

- General notions regarding administrative proceedings and measures. The principles of Law no. 241/1990 on administrative proceedings
- Administrative activity in the field of energy (programming and planning, authorization and granting powers, public subsidies)
- Purposes and tools of independent regulation. The principles of Law no. 481/1995 and the functions of the Authority for the Regulation of Networks, Energy and the Environment (ARERA). Regulatory competences between European and national levels
- The transformation and current structure of the electricity and natural gas markets.

B. Special Part

- The procedure for adopting independent regulatory acts
- Structure and regulation of the electricity and natural gas market. Role and functions of the parties involved (ARERA, network manager, GSE, GME, AU, CSEA)
- The (complex) relationship between energy, environment and territory. The notion of environment and landscape
- Authorization procedures for the construction and operation of production plants and grid connection works. Environmental impact assessment procedures.
- The case of renewable energy sources (RES). Potential "scalar" conflicts between environmental interests (prevention of climate change vs protection of territory and landscape)
- The regulation of the main energy incentive tools (renewable sources and energy efficiency)
- The role of the Energy Services Manager (GSE). Method of attribution of incentives and control system. Administrative litigation regarding incentives.

Focus and thematic insights*

- The discipline of the so-called special government powers (golden powers) in matters of energy
- Procurement in the energy market

*(also in seminar settings, with possible participation of external guests)

Sustainable Development Goals (SDGs)

This course contributes to achieve the following Sustainable Development Goals:

SDG7 – AFFORDABLE AND CLEAN ENERGY

Bibliography

No specific pre-requisites.

057870 Diversity Aware Design of Technology Solutions
(5 ECTS credits)

This course is offered in the:

Spring Semester (Feb – May)

Short description.

In numerous contexts, technology is experiencing disruptive changes that will cause severe discontinuities with respect to the status quo and will substantially alter the interactions between individuals and society at large. At the same time, topical societal challenges are occurring, such as the gender gap, the digital divide, a widespread ageing and an ever-increasing multiculturalism. These two complex realities share only vague tangency points, while they should deeply intertwine.

This course offers an interdisciplinary view on these topics, combining the disciplines of sociology and engineering. It will discuss why and how the different stages of technology design, ranging from user characterization, to adoption mechanisms, incentive policies and actual deployment of systems and services should consider socio-economic variables that capture the diversity dimensions defining the different individuals, thus shaping their relationship with technology itself. The most relevant analytical dimensions driving the scene relate to the main structures of inequality in society: a) gender; b) age c) ethnicity; d) class; e) urban/rural divide. These sources of diversity will be presented and discussed within an intersectional sociological framework, i.e., considering how these different socio-economic aspects interact when more than one is present in a single individual.

097370 Economics and Management of Multinational Enterprises

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

Globalization has created new growth opportunities for companies by accessing resources and serving markets worldwide. This course focuses on the strategic and organizational challenges involved in managing activities across borders (e.g. different cultures, administrative systems, geographic distances) in an increasingly interconnected world. Students will be provided with frameworks that help them to understand: Why firms do (or don't do) international business? How do they do it? What are the international strategies firms use as they go overseas? How firms build a global presence by choosing countries, products and modes of entry? How firms organize for international business? The course will combine the development of conceptual frameworks primarily through lectures with in class analysis and discussion of key cases.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
  At the end of this course the students should understand the nature of the global environment and how to compete internationally. Student understanding of these concepts will be assessed through a final examination.
- Identify trends, technologies and key methodologies in a specific domain (specialization streams
  At the end of the course the students should understand the main theories in international business. This knowledge will be assessed through a final examination.
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members
  Students will be able to show their ability to interact in a professional, responsible, effective and constructive manner through their participation in a group project. The project will be presented in class and will count for 50% of the final grade.

Topics Covered

1. Definitions, data and trends on multinational enterprises and foreign direct investment
    - 1.1. Multinational companies: what are they?
    - 1.2. Data and trends
    - 1.3. Historical evolution
2. How reliable and meaningful are our existing international trade and investment statistics
    - 2.1. Trade statistics
    - 2.2. Investment statistics
3. Distance in international business
    - 3.1. Geographical distance
    - 3.2. Culture and cultural distance
    - 3.3. Institutions and institutional distance
4. Why do firms expand abroad? Theories of the Multinational Enterprise
    - 4.1. Interest rate theory
    - 4.2. Industrial organization theory
    - 4.3. The product life cycle
    - 4.4. Eclectic theory (OLI)
    - 4.5. Internalization theory
    - 4.6. Transaction cost theory
    - 4.7. Resource-based view
5. The rise of new players: Emerging Market multinationals
6. Speed and scope of international expansion
    - 6.1. The Uppsala Internationalization Process Model
    - 6.2. Born Globals
    - 6.3. Internationalization of family firms
7. International modes of entry and operation
    - 7.1. The bundling model of entry and operation
    - 7.2. Licensing and franchising vs. foreign direct investment
    - 7.3. Alliances and joint ventures
    - 7.4. Greenfield entry vs. mergers and acquisitions
8. Strategies and organizational structures of multinational enterprises
    - 8.1. Global, transnational and multi-domestic strategies
    - 8.2. Functional, product, area, mixed and matrix structures
9. Control in multinational enterprises and the balanced scorecard

Bibliography

- Slides and case studies available on Beep
- Articles and book chapters available on Beep

057253 Economics and Performance of the Healthcare Sector
(5 ECTS credits)

The course is offered in the:

Spring Semester [Second half-semester (Mid of April – End of May)]

Prerequisites

No pre-requisites required.

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members.

Expected Learning Outcomes

Students will be able to:

- Understand and describe the different measures of inputs, outputs and outcomes related to the activities of the healthcare sector, the purposes of each type of measure and how performance measurement can be a useful information tool for healthcare policies and managerial decisions;
- Critically analyse and appraise the results of performance measurement for improving the outcome of policy and managerial decision-making, at the healthcare system level as well as at the healthcare providers level, understanding the key success factors and the challenges to its successful use.

Topics Covered

Setting the context of performance measurement: a brief introduction to the functioning of healthcare systems

- The architecture of healthcare systems
- Organization, financing, and delivery of healthcare services

Issues, methodologies and use of performance measurement in healthcare

- A framework for the measurement of performance in healthcare
- The different dimensions of performance
    - Health
    - Clinical quality and appropriateness
    - Financial protection
    - Equity

- Efficiency

To provide students with the necessary skills to operationalize the theoretical concepts related to performance measurement, their presentation in the lectures will be followed by a practice class discussion of applied work related to the different measures. Special attention will be devoted to the data to be used, to their sources and to their appropriate treatment for the application of the different methodologies. A detailed schedule with the dates and the topics dealt with in the lectures and in the practice, classes will be provided before the beginning of the course on the BeeP platform.

Bibliography

Main textbooks.

Irene Papanicolas and Peter C. Smith (eds), Health system performance comparison, Editore: Open University Press McGraw-Hill Education, Anno edition: 2013, ISBN: 978-0-33-524726-4 https://www.euro.who.int/__data/assets/pdf_file/0009/244836/Health-System-Performance-Comparison.pdf (Relevant chapters: 5, 6, 7, 8, 9, 10)

058223 Economics for Development
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No particular pre-requisites.

Learning Objectives

The principle of development economics are key to understanding how we got to where we are, and why many development problems are so difficult to solve, and to the design of successful development policy and programs.

The first goal of this course is to ensure that students understand real conditions and institutions across the developing world. The second is to help students develop analytic skills while broadening their perspectives of the wide scope of the field. The third is to provide students with the resources to draw independent conclusions as they confront development problems, their sometimes ambiguous evidence, and real-life development policy choice.

Expected Learning Outcomes

On successful completion of this course, students will be able to: 1. Demonstrate familiarity with some central themes and issues of economic development. 2. Demonstrate the understanding of the difference between growth and development, major growth theories, the measurement of inequality, significance of poverty, international trade, and role of foreign investments. 3. Discuss competing theories of economic development; 4. Analyse empirical evidence on the patterns of economic development. 5. Read critically the journal literature and draw independent conclusions as they confront development problems, their sometimes ambiguous evidence, and real-life development policy choice (also thanks to the 6-8 training sessions held in collaboration with UN).
On a voluntary base, students can also attend the Polimi MOOC "Entrepreneurship without borders" .

Topics Covered

- ***Introducing Global Development***

Traditional economic measures and the new economic view of development. The Millennium Development Goals.
Textbooks: Todaro M.P., Smith S.C. Economic Development, 12th Edition. Addison Wesley, ch.1-2
De Janvry A., Saudolet E. (2016). Development Economics: Theory and Practice. Routledge, ch. 1.
Readings
Sachs JD, Mellinger AD, Gallup JL. 2001. The geography of poverty and wealth. Scientific American. March; 284(3):70-5.

- ***Poverty, inequality and development***

Measuring inequality and poverty.
Textbook: Todaro M.P., Smith S.C. Economic Development, 12th Edition. Addison Wesley, ch. 5
Readings
Foster J., Seth S., Lokshin M., Sajaia Z. 2013. A unified approach to measuring poverty and inequality. Theory and practice. The World Bank.

Deaton A. 2021, Covid-19 and global income inequality. Working Paper 28392. February 2021 http://www.nber.org/papers/w28392

Rao Fu, Gui Jin, Jinyue Chen, Yuyao Ye (2021). The effects of poverty alleviation investment on carbon emissions in China based on the multiregional input–output model, Technological Forecasting and Social Change, 10.1016/j.techfore.2020.120344, 162.

- ***Classic Theories of Economic Growth and Development***

Development as growth and the linear stages theories. Structural change models. The international-dependence revolution, and the neoclassical counterrevolution.

Textbook: Todaro M.P., Smith S.C. Economic Development, 12th Edition. Addison Wesley, ch. 3

Readings

Diao X., Ellis M. McMillan M.S., Rodrik D. 2021. Africa's Manufacturing Puzzle: Evidence from Tanzanian and Ethiopian Firms. DOI 10.3386/w28344. NBER Working Paper 28344. January 2021

Korinek A., Stiglitz J.E. 2021. Artificial Intelligence, Globalization, and Strategies for Economic Development. NBER Working Paper 28453 http://www.nber.org/papers/w28453

- ***Contemporary Models of Development and Underdevelopment***

Underdevelopment as a coordination failure. The Big-Push. Amartya Sen: The capability approach.

Textbook: Todaro M.P., Smith S.C. Economic Development, 12th Edition. Addison Wesley, ch. 4

Readings

Easterly W. 2006. Reliving the 1950s: the big push, poverty traps, and takeoffs in economic development, Journal of Economic Growth, Volume 11, Issue 4, pp 289–318

- ***Institutions and development***

Textbook: De Janvry A., Saudolet E. (2016). Development Economics: Theory and Practice. Routledge, chapter 20.

Readings

Abramovitz, M. (1986). Catching Up, Forging Ahead, and Falling Behind. Journal of Economic History, 46:2, pp. 385-406.

Acemoglu D., Smith J. The role of institutions in growth and development, Review of Economics and Institutions, 2010, vol. 1, no. 2, pp. 1-33.

Acemoglu D., Johnson S., Robinson J. 2001. The colonial origins of Comparative Development: An Empirical Investigation, American Economic Review, Vol. 91, No. 5 (Dec., 2001), pp. 1369-1401.

- ***International Trade Theory and Development Strategy***

Traditional trade strategies for development: Export promotion vs. import substitution. South-south trade and economic integration

Textbook: Todaro M.P., Smith S.C. Economic Development, 12th Edition. Addison Wesley, chapter 12

Readings

Harrison A. 1996. Openness and growth: A time-series, cross-country analysis for developing countries, Journal of Development Economics 48 (2), 419-447

Hanson GH, Harrison A. 1999. Trade liberalization and wage inequality in Mexico, ILR Review 52 (2), 271-288.

- ***Multinational Enterprises, Global Value Chains, and local development.***

Textbook: Todaro M.P., Smith S.C. Economic Development, 12th Edition. Addison Wesley, chapter 14

Readings

Aitken B.J., Harrison A.E. 1999. "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela," American Economic Review, vol. 89(3), pages 605-618.

Amendolagine V., Boly A., Coniglio N.D., Prota F., Seric A., 2013. FDI and Local Linkages in Developing Countries: Evidence from Sub-Saharan Africa. World Development, Volume 50, pp. 41-56.

Haddad M, Harrison A. 1993. Are there positive spillovers from direct foreign investment? Evidence from panel data for Morocco, Journal of Development Economics, 42 (1), 51-74.

Eskeland GS, Harrison AE. 2003. Moving to greener pastures? Multinationals and the pollution haven hypothesis, Journal of Development Economics, 70 (1), 1-23.

- ***Impact evaluation of development policies and programs***

Textbook: De Janvry A., Saudolet E. (2016). Development Economics: Theory and Practice. Routledge, ch. 4.

Readings

Galiani S., Gertler P., Schargrodsky E. (2005), Water for life: The impact of the privatization of water services on child mortality, Journal of Political Economy 113(1): 83-120.
Guidolin M., La Ferrara E. 2007, Diamonds are forever, wars are not: is conflict bad for private firms?, American Economic Review, 97(5): 1978-93

- ***New advances in behavioral economics and development***

Textbook: De Janvry A., Saudolet E. (2016). Development Economics: Theory and Practice. Routledge, ch. 4.
Readings
Duflo E. 2020. Field Experiments and the Practice of Policy. American Economic Review, 110(7): 1952–1973
Servet J-M., Tinel B., (2020). The behavioral and neoliberal foundations of randomizations, Strategic Change, 10.1002/jsc.2328, 29, 3, (293-299).

- ***Sustainable Development Goals (UN Lab)***

Readings
Montiel. I., Cuervo-Cazurra, A., Park, J., Antolin-Lopez, R., Husted, B.W. 2021. Implementing the United Nations' Sustainable Development Goals in International Business. Journal of International Business Studies 52(5): 999-1030.
Materials provided by the UN Instructor.

Sustainable Development Goals (SDGs)

This course contributes to achieve the following Sustainable Development Goals:

- **SDG1 – NO POVERTY**
- **SDG 8 - DECENT WORK AND ECONOMIC GROWTH**
- **SDG1 7 - PARTNERSHIP FOR THE GOALS**

Bibliography

Please see the references to each subject in the dedicated field

057046 Economics of Innovation and New Technologies

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Students should master basic concepts in theories of the firm, competitive structures, and business strategies.

Learning Objectives

The course fits into the overall program curriculum in Management Engineering by contributing to achieve its general learning goals. Specifically, the course develops the following Learning Objectives: “understanding context, functions, processes in a business and industrial environment and the impact of these factors on business performance”. To achieve its aim the course combines frontal and interacting lectures (i.e., flipped classrooms, see below).

Expected Learning Outcomes

By attending the course, students learn to:

- Understand the economic rationales that drive firms’ innovation decisions, thus being able to make sense of firms’ innovation investments and, ultimately, of the impact of these investments on firms’ performances [Assessed through the written exam].
- Advise firms on how to orient their innovation investments to maximize efficiency and the impact on performances [Assessed through the written exam].
- Understand the economic rationales that guide policymakers (and institutions in general) to support innovation, thus being able to make sense of innovation policies and, ultimately, of their impact on the innovation performances of firms, industries, and economic systems [Assessed through the written exam].
- Advise policymakers on how to design innovation policies to effectively stimulate innovation [Assessed through the written exam].
- Analyse case studies (revolving around points 1-4), which describe real-world situations, by applying theoretical and empirical knowledge on economics of innovation [Assessed through the flipped classrooms].
- Perform the analysis sub 5 in teams and present their work during structured discussion sessions [Assessed through the flipped classrooms].

Topics Covered

Nowadays, new technologies emerge one after the other and technological knowledge advances at full speed. In this context, everybody agrees that innovation is the main leverage through which firms can gain a sustainable competitive advantage and achieve superior performance. Accordingly, understanding the economic antecedents and consequences behind firms’ innovation decisions, and being able to maximize the outcomes these decisions is a key capability for succeeding on the labour market. Likewise, innovation is the main engine of economic growth and policymakers (and institutions in general) actively engage in supporting it. Hence, it is of paramount importance to develop awareness on the economic rationales behind this support so as to take advantage of the associated policy schemes. Moving from these premises, this course illustrates conceptual foundations and real-world evidence about:

- The role of innovation and new technologies in modern economic systems (module 1).
- The drivers of the adoption of new technologies, with a focus on uncertainty and limited rationality as barriers to this adoption (module 2).
- The relation between firms' innovation and competition, with a focus on appropriability regimes, market structures, and market imperfections (module 3).
- The antecedents and economics consequences of inter-firm agreements for innovation, with a focus on alliances and acquisitions (module 4).
- The role of institutions in innovation, with a focus on public support to innovation, policy schemes for stimulating innovation, and relations between informal institutions and innovation (module 5).

Bibliography

The course does not base on a unique textbook. Course materials consist of a collection of slides, case studies, scientific papers, book chapters, videos, etc, that the teachers make available through the EINT page on WeBeep.

052589 Electricity Markets
(8.0 ECTS credits)

The course is offered in the:

First Semester (Sep – Dec)

Prerequisites

Ancillary services, reliability and security for electricity system, N and N-1 security criteria, Total Transfer Capacity (TTC) definition and calculation, primary and secondary frequency control, voltage control.

Learning Objectives

The course aims to provide a deep understanding regarding the liberalization process of the electricity sector and its evolution in a liberalized environment. In the first part, tools to understand the process of liberalization of the electricity sector, the requirements and the conditions necessary for an efficient electricity market will be provided. Different market structures are compared and analysed. Afterwards, models for price and power market analysis will be introduced.
In the second part, emphasis will be given to the European electricity market: the problem of the market coupling in Europe is analyzed and the evolution and the projects regarding the integration of the different market sections (day ahead electricity markets, intraday markets, and ancillary services markets) is analyzed.
Finally, starting from the liberalization of the Italian electricity market, due to the Bersani Decree, the complex framework that characterizes this market and its rules will be described and critically analyzed. The subjects are organized in theoretical lessons and practical (numerical) lessons. Then, a simulation of the pool market paradigm will be organized and the students (divided in teams) will assume the role of a generation company. Each team will have to define the strategy and will have to submit offers in the market. This simulation will be repeated several times to give the possibility to learn and understand the best strategy for its own generation company.

Expected Learning Outcomes

The course will allow the students to know (DdD1, DdD4):

- What are the prerequisites for the liberalization of the electricity market;
- What are the market structures in the electricity sector;
- How the technical constraints (due to the generation plants and the electricity grid) influence the design of the electricity market;
- What are the different approaches to represent the network in the market models;
- The evolution of the market paradigms due to the penetration of the non-programmable renewable energy sources;
- To evolution of the market coupling project in Europe;
- The Cross-Border Redispatch Cost-Sharing problem among different Countries.

The practical (numerical) lessons of the course will allow the students to (DdD2, DdD4):

- Understand how it is possible to implement (from a mathematical point of view) an electricity market model;
- Apply the optimization theory and algorithms for modelling electricity markets;

Finally, the simulation of the pool market will allow the students to apply the theoretical knowledge to understand which are the factors that affect the strategic behavior of the market player in the day ahead electricity market section (DdD2).

Topics Covered

- Electrical systems management in liberalized markets environment: liberalization process from vertically integrated structures to liberalized markets, the players and their role.
- Main electricity markets paradigms: bilateral contracts and pool market models.
- Power electricity exchange (PX) and the role of the Transmission System Operator (TSO): electricity market models and congestion management. Transmission capacity value.
- Ancillary Services and Ancillary Services Market: description of ancillary services and their management in special market (ancillary services markets).
- The evolution of the ancillary services markets.
- Capacity market.
- Imperfect competition; market power and promotion of competition: tools for market power analysis, game theory. Strategic interaction between day-ahead market and the ancillary services markets.
- The Italian spot electricity market (MPE: mercato a pronti): structure and rules. MGP (Mercato del Giorno Prima), MI (Mercato Infragiornaliero), MSD (Mercato dei Servizi di Dispacciamento) and MB (Mercato di Bilanciamento).
- The Italian Forward Electricity Market (MTE: mercato a termine): characteristics and rules. Interaction with the spot market.
- Market coupling project in Europe.

Bibliography

Main textbooks

Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé, Power Generation, Operation, and Control, 3rd Edition, Wiley, New York, 2013, ISBN: 978-0-471-79055-6 https://www.wiley.com/en-us/Power+Generation%2C+Operation%2C+and+Control%2C+3rd+Edition-p-9780471790556

Recommended materials

Chris Harris, Electricity Markets: Pricing, Structures and Economics, John Wiley & Sons Ltd, 2013, ISBN: 9780470011584 https://onlinelibrary.wiley.com/doi/book/10.1002/9781118673409

055807 Emerging Technologies and Societal Challenges
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

The course aims at cultivating a critical approach to the understanding of technology and innovation. Particularly, it aims at showing how the decision to develop a technological application and the processes of its design, development, management, control, and production are inherently social. It is intended to give students a chance to reflect on the ethical, societal, and cultural impact of technological applications. The impact of emerging technologies will be addressed focusing on some key features of technological innovation: complexity, cultural variables, non-linear character, ethical implications. The first module will address the basic terminology of innovation studies and some fundamental issues of technological innovation. The general aim is to show that innovation is not a linear process that can be designed and driven top-down, but a complex one governed by multiple alternative forces. The second module will address more in detail some specific issues raised by emerging technologies. By adopting an interactive and participatory approach, Module 2 will allow time for discussion, peer-to-peer learning and cross-fertilization on specific societal challenges related to the most striking cases of emerging technologies.

Expected Learning Outcomes

Students will:

- Acquire a broad perspective on the ethical and social impacts and implications of science and technology;
- Learn how to recognize and analyse ethical and social aspects and issues inherent in emerging technologies;
- Be able to understand how technical problems are inherently connected to a social dimension within a socio-technical perspective.
- Be able to use critical skills in clarifying and analysing case-studies involving technology;
- Be able to apply sociological theories to problems created, aggravated or transformed by current technologies;
- Be able to explore and assess possibilities for addressing social problems generate by emerging technologies.
- Be able to autonomously analyse the social impact of a technology and to develop a critical analysis on that;
- Be able to evaluate and select the appropriate knowledge in the effort of understanding and addressing social problems generated by technology.
- Learn to exercise and improve their skills in a critical writing;
- Learn to present in an effective way the results of their independent research, being able to justify their choices.
- Be better prepared to their future professional life in a socially responsible way;

- Be able to analyse problems through a theoretical lens.

Topics Covered

The course is structured in two modules of about the same length.

Module 1
It consists of a series of interactive lectures dealing with major topics of innovation theories. Both conceptual aspects: technology push vs. market pull innovation, radical and incremental innovation, innovation of product and process, etc; and theoretical approaches: diffusion of innovations, technological determinism, the agency of technological objects, interpretative flexibility of technology, gender and technology, etc.
The active participation of students during classes is strongly encouraged.

Module 2
The second module is based on case studies and addresses four emerging technologies with relevant impact on society and human life:

- The Internet of Things
- Digital Fabrication
- Blockchain and Decentralized Autonomous Organizations
- Artificial Intelligence and Machine Learning

Instead of focusing on the working, performances, and technical issues of these technologies, the module will address the ethical issues that they raise and societal impacts that they produce.
This part of the course will be carried out in the form of symposia, in which students will have to present and discuss in small groups (according to the "flipped classroom" method) a specific case related to the four technologies mentioned above, and deliver a final essay.

Bibliography

Main textbooks

Adam Greenfield, Radical Technologies, Anno edition: 2017

Everett Rogers, Elements of diffusion, Anno edition: 2003

Note: Chapter of the book Diffusion of Innovations, pp. 1-38

Judy Wajcman, Domestic Technology: Labour Saving or Enslaving? Anno edition: 2010

Note: Chapter of the book Technology and Values: Essential Readings, pp. 273-288

Bruno Latour, Where are the missing masses?, Anno edition: 1992

Note: Chapter of the book Shaping technology/Building society: Studies in sociotechnical change, pp. 225-258

Wiebe Bijker, King of the road: The social construction of the safety bicycle, Anno edition: 1995

Note: Chapter of the book Of Bicycles, Bakelites, and Bulbs, The MIT Press, pp. 19-100

057905 Energy Accounting and Impact Assessment Methods

(8 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Basics of linear algebra (fundamental). Basic knowledge of MS Excel (fundamental) and Python programming language (optional).

Learning Objectives

The main goal of the course is to introduce students to the fundamentals of quantitative impact assessment methods and models. These quantitative models are specifically aimed at assessing the prospective environmental and economic impacts resulting from the application of technological or policy interventions at meso- and macro-scale, comprehensively including supply-chain effects in a Life Cycle perspective. First, basic principles of systems modelling, quantitative impact assessment and Industrial Ecology are introduced and discussed also based on real life examples and case studies. In the second part of the course mathematical basis of impact assessment models are introduced, focusing on Leontief's Input-Output framework. The third part of the course is devoted to the analysis of energy, environmental and economic national accounting frameworks, mapping the structure of national supply chains, hence usually adopted as databases for impact assessment models. In the fourth part of the course, the introduced methods and datasets are adopted to define basic and advanced impact assessment models.

Expected Learning Outcomes

Knowledge and understanding. The students learn basic concepts of Impact assessment methods, Life Cycle Assessment and Industrial Ecology. They understand how physical and monetary flows of goods and services are produced and consumed within a generic productive system, and how they are accounted in standard accounting frameworks. They learn basics of impact assessment and LCA modelling.

Applying knowledge and understanding. The students are able to setup an impact assessment model from scratch to perform quantitative analyses of shocks at meso- and macro-scale. They are able to define the appropriate approach and to select complexities to be modelled based on the type of policy/technology shock to be analyzed

Making judgements. The students are able to quantify policy/technology shock at the meso- and large-scale based on different impact indicators (energy, environmental, economic dimensions). They will be able to perform scenario analysis based on the reference production system at country level, evaluating the effect of a different technology deployment.

Topics Covered

Topic 1 – Principles of Quantitative Sustainability Assessment (QSA). Current challenges in quantitative sustainability assessment, approaches to model productive systems, principles of Industrial Ecology and Life Cycle Assessment. Impact assessment: practical examples and real case studies.

Topic 2 – Computational structure of impact assessment models. The Leontief's Input-Output framework. Supply and Use models: nomenclature, balance equations, setup and application for impact assessment and LCA. Modelling productive systems and handling systems' complexities.

Topic 3 – Fundamentals of energy, environmental and economic accountings. Overview of national accounting frameworks, standard classification of products and activities. Single-region and Multi-regional accounting tables. Handling and transforming national accountings to perform impact assessment and LCA.

Topic 4 – Applications of impact assessment models. Review and taxonomy of available modelling approaches. Definition and use of Process-based models, Input-Output based models, Hybrid models. Application of attributional and consequential LCA and impact assessment. Application to a real case study based on a model built from scratch.

Sustainable Development Goals (SDGs)

This course contributes to achieve the following Sustainable Development Goals:

- **SDG7 - AFFORDABLE AND CLEAN ENERGY**
- **SDG12 - RESPONSIBLE CONSUMPTION AND PRODUCTION**
- **SDG13 - CLIMATE ACTION**

The introduction lectures present the topic of quantitative impact assessment and its links with SDGs in general (about 1-2 hours lecture). Methods and models presented during the course enable to derive quantitative results to assess the prospective effects that policy actions or technology changes may have on productive systems. Therefore, these results provide adequate ground to elaborate a discussion around the achievement of SDGs. Students discuss these aspects as one of the main outcomes of the project work activity. Due to the nature of the adopted models, discussion is focused on SDGs 7, 13 (energy and climate). Beside these topics, however, the adopted modelling framework comprehensively includes all industrial sectors within a national economy, hence stimulating a discussion also around SDG 12.

Bibliography

Main textbooks

Slides, tutorials and hands on provided during the course

Miller, Ronald E., and Peter D. Blair, Input-output analysis: foundations and extensions, Editore: Cambridge university press, 2009

Leimkuhler, Ferdinand F., Introduction to operations research, Editore: McGraw Hill, 2015

Recommended materials

Eurostat, Eurostat manual of supply, use and input-output tables, Editore: Eurostat methodologies and working papers, 2008

Scientific papers provided during the course

055635 Energy and Climate Change Modeling and Scenarios
(8 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Keen interest in global climate change and other environmental issues. Excellent knowledge of programming skills (ie. Matlab, Python, R).

Learning Objectives

The main objective of the course is to study climate change challenge using quantitative, numerical tools. Specifically, the aim is to learn the basic elements of the global energy and climate problems, evaluate the solutions with a focus on the energy sector, and use optimization and simulation models to evaluate the emission reduction and adaptation strategies. To do so, a discussion of the fundamentals of the global economy, energy, land and climate systems will be complemented by development and applications of mathematical models which integrate these key components. The course will also teach programming languages used in energy-climate planning, such as GAMS, and R. The course uses innovative teaching methods, in particular it is a flipped classroom course: students will form groups of 4/5 students and work on projects to improve one or more numerical integrated models to deal with climate change solutions, either on mitigation or adaptation.

Students based in Leonardo (i.e. Mathematical Engineers) can attend part of the course virtually.

Expected Learning Outcomes

- Knowledge and understanding: the students will learn what is global warming, how it affects the energy and economic systems, and what are the main solution strategies.
- Applying knowledge and understanding: the students will apply the theoretical concepts to numerical models that mimic the energy and climate systems
- Making judgements: the students will analyse the results of the models and will have to interpret then correctly, identifying robust results
- Communication skills: the students will present in class a project, and thus will need to create a presentation and be able to communicate it properly
- Learning skills: the students will learn how to use computer programs like GAMS, R and Python
- Knowledge of the global climate and energy challenges
- Programming for scientific computing
- Data analysis and visualization
- Presentation skills

Topics Covered

Topic 1: Introduction to the global grand challenges: economy, energy, land, water and climate
Topic 2: Fundamentals of climate economics
Topic 3: Introducing the tools of Integrated Assessment Models

Topic 4: Mathematical Modelling and Optimization using the GAMS language
Topic 5: The simplest integrated energy-economy-climate model: the DICE model
Topic 6: Increasing complexities: energy systems, air pollution, land use and water use
Topic 7: Model calibration, diagnostics and validation
Topic 8: The role of technology and its progress towards a low carbon economy
Topic 9: Energy, economic development and green growth
Topic 10: Accounting for Risks and Uncertainty: Monte Carlo and stochastic programming modeling applications
Topic 11: Global Environmental Policies and Agreements. Modeling strategic interactions
Topic 12: Modeling European energy and climate policies
Topic 13: Statistical analysis of the past and projected drivers of the global grand challenges using R Studio

Bibliography

Main textbooks

DICE 2013: http://www.econ.yale.edu/~nordhaus/homepage/documents/DICE_Manual_100413r1.pdf

Recommended materials

Global Energy Assessment - Toward a Sustainable Future, Editore: Cambridge University Press, 2012: http://www.globalenergyassessment.org/

IPCC 5th assessment report, WGIII, 2014: http://mitigation2014.org/

052398 Energy Conversion B

(8 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

The prerequisite knowledge convers the topics in classic thermodynamics, fluid machines and energy systems.

Learning Objectives

The goal of the course is providing the students with the knowledge and the competence to understand inherently, design preliminarily (i.e. employing only paper, pencil and a calculator), model accurately (i.e. employing also a computer and a simulation code), and optimize conventional and unconventional power plants from energy, economic, environmental and technical perspectives. The goal is pursued by way of traditional teaching methods as well as of innovative ones including mandatory and non-mandatory small-group activities.

Expected Learning Outcomes

Regarding conventional power plants, the student will be able to:

- describe the modelling approaches for the working fluids, the main equipment (like heat exchangers and turbomachines) and the single as well as overall process;
- explain the typical choices of the design parameters for working fluids, operating conditions, main equipment, and processes;
- sketch the cycles and the processes on selected thermodynamic charts as well as on the process flow diagrams (also referred to as layouts);
- compute and comment the typical performances and irreversibility of the main equipment and the processes.

Moreover, regarding conventional and unconventional power plants, he/she will be able to:

- select the most promising layouts for diverse hot sources and/or cold sinks;
- size with a good approximation the main equipment (like heat exchangers and turbomachines);
- predict the performances in on- and off-design operation of the main equipment and the processes;
- mitigate the typical irreversibility of the main equipment and the processes.

Lastly, he/she will be able to:

- improve autonomously and continuously the detailed knowledge in power plants;
- read and understand generic industrial processes other than power plants;
- develop new concepts for power plants and industrial processes.

Topics Covered

The course covers the electricity generation in power plants, focusing in particular on the inherent relation among working fluids, thermodynamic cycles and main equipment. Thermodynamic and technical aspects are addressed in details, whereas economic, management, environmental, and strategic aspects are presented as necessary. The developed concepts can be applied indifferently to fossil fuel-fired power plants, as well as to waste-heat-recovery systems, renewable sources (in particular, biomass, biogas, biomethane and concentrated solar), and also to generic industrial processes-.
The course comprises lectures, numerical exercise hours, computer lab hours on the 5 assigned project works (developing own or employing existing simulation codes), and technical visits at equipment manufacturers and power plants (if possible). Part of the course (1 credit) is provided as innovative learning, through mandatory project works solved by students in teams, for which guidelines are anyhow provided, and optional assigned homework solved also in teams, which are anyhow discussed in class with the participation of the students.
The specific topics are as follows, some of which provided by way of the group activities.

- Working fluids: Thermodynamic properties. Ideal gases and real fluids (vapours and liquids); phase change; combustion and fuels, both fossil and renewable; influence on the design of turbomachines, heat exchanger, and power plant (conventional and unconventional cycles, open and closed cycles).
- Power plants: Second-law analysis. Energy as well as entropy balances of diverse power plants (open and close, fossil and renewable); physical meaning of entropy; matching of the heat source and the cycles; irreversibility; first and second-law performances.
    - Advanced steam power plants. Historical evolution of pulverized-coal power plants; focus on ultra-supercritical power plants; second-law analysis; control logics, plant governing, and emission abetment; future developments.
    - Advanced gas turbines and combined cycle. Historical evolution and state-of-the-art of gas turbines; second-law analysis and future developments.
    - Closed gas cycles. Applications; generalized theory; analysis of the recuperator; partial-load governing; full-load and partial-load performances.
    - Nuclear power plants. Overview of nuclear reactors; choice of nuclear source, moderating fluid, cooling fluid and thermodynamic cycle; overview of nuclear power plants; choice of operational parameters for selected technologies.
- Turbomachinery: One-dimension analysis. Geometries and definitions; stage optimization by way of free variable, objective functions and constraints; velocity triangles and limits related to transonic and supersonic flows; effect of geometrical parameters on stage efficiency; similitude theory and influence of the working fluid on the geometry and performance.

Class notes will be provided at the beginning of the course, presentations will be published just before the classes as well as the computer lab hours, and specific readings (in addition to the bibliography listed below) will be suggested throughout the course.

Bibliography

Recommended materials

M.J. Moran, H.N. Shapiro, D.D. Boettner, M.B. Bailey, Principles of Engineering Thermodynamics, 8th Edition SI Version, Editore: John Wiley & Sons, Anno edition: 2015, ISBN: 978-1-118-96088-2

W.C. Reynolds, P. Colonna, Thermodynamics - Fundamentals and Engineering Applications, Editore: Cambridge University Presso, Anno edition: 2018, ISBN: 9780521862738

P. Kiameh, Power Generation Handbook. 2nd Edition Power Generation Handbook. 2nd Edition, Editore: McGraw-Hill, Anno edition: 2011

E.P. Gyftopoulos, G.P. Beretta, Thermodynamics: Foundations and Applications, Editore: Dover publications, 2005: https://ebookcentral.proquest.com/lib/polimi/detail.action?docID=4890763

055634 Energy Economics
(8 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No prerequisites required.

Learning Objectives

Over the last two decades, an increasing number of countries around the world has replaced vertical integration with markets as the main methods of organizing the "energy" industries. This course discusses the way in which these markets have put economic principles into practice and provides insights on the topics that are currently on the frontier of the research and policy agenda. In particular, the course will provide the frameworks, models and tools to understand the functioning of the energy markets. The instructors will provide theoretical model and empirical evidence to guide the students in the process of understanding the context, and the motivations behind public intervention in energy market as of well as the functioning of competitive wholesale markets. An important part of the course will be devoted to describe how environmental externalities influence public intervention in the energy market. During class activities, students will be asked to apply the theoretical models to real cases and formulate autonomous judgement about the choices made by the players in the energy market. The course will involve guest speakers, who will share their practical experience with the class, and will include teamwork actives designed to involve students actively in the learning process.

Expected Learning Outcomes

At the end of the course, the students can:

- Describe the functioning of energy markets
- Identify "natural monopolies" and describe why regulatory intervention is necessary to improve welfare
- Describe the context, and the motivations behind public intervention in energy market;
- Describe the functioning of competitive wholesale markets
- Describe how the environmental externalities influence the energy markets
- Evaluate the most efficient mode of externality regulation
- Describe the specific challenges for the players in the energy sectors
- Apply theories of energy economics to real-world situations

Topics Covered

The course includes:

- Lecture sessions: they aim at illustrating, sharing and discussing models, conceptual frameworks, tools and empirical evidence.
- In-class case study discussions: they aim at making students apply the insights from theory and empirics to real world situations. Students have to read case study materials in advance of the class sections.

- Workgroup: students will conduct a literature review and/or statistical analysis on selected topics related to the course

Bibliography

No texts suggested.

052896 Energy Management LAB
(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No strong prerequisites. Students are expected to know the principles of energy management, which are covered in courses "Management of Energy".

Learning Objectives

This course is designed to provide students with the concepts and instruments necessary for a) assessing from an economic perspective the adoption of technologies in the renewable energy, energy efficiency and digital domains; b) understanding the impact of emerging societal, technological, economic and regulatory-political trends on the business models of companies in the energy value chain; c) understanding and analysing industrial practices in terms of their energy performance and identifying the potential of energy-efficient technologies and services within the energy value chain. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business, industrial and societal environment
- Develop new ideas and transformative solutions to deliver positive impact on business, industrial and societal scenarios evolving over time
- Interact in a professional, responsible, inclusive, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

A student that has successfully attended the course is expected to be able to:

- Identify and apply appropriate methods and tools for the economic evaluation of investments in renewable energy, energy efficiency and smart grid technologies.
- Identify and apply appropriate instruments for assessment of energy efficiency.
- Identify drivers and barriers for adoption of energy-efficient technologies and services.
- Discern and develop the most appropriate measures and implementation approaches for energy efficiency.
- Understand the emerging societal, technological, economic and regulatory-political trends and their implications in terms of managerial and organizational issues as well as for the economic/environmental assessment of enabling technologies.
- Develop new solutions and ideas and present them in a professional and constructive way, fostering the value of the teamwork, and using a language adequate to both managers and fellow students

Topics Covered

- Economic assessment of investments in Renewable Energy Sources**:** Advanced tools and methodologies for the economic assessment of investments in energy-related industries.
- Economic assessment of investments in Energy Storage Systems and other smart grid enabling technologies**:** Advanced tools and methodologies for the economic assessment of investments in energy related industries.
- Economic assessment of investments in Energy Communities domain**:** Advanced tools and methodologies for the economic assessment of investments in energy related industries.
- Energy Scenarios and emerging business models**:** societal, technological, economic and regulatory-political trends affecting business models of companies in the energy value chain.
- Industrial energy use and efficiency**:** relevance of energy issues for corporate performance; opportunities for energy efficiency improvements in industry.
- Energy efficiency measures in industry**:** main measures per sector, firm size; characterization of the measures.
- Assessment methods for energy efficiency**:** methods based on benchmarking with BAT/Ps; methods based on waste accounting.
- Adoption of energy efficiency measures**:** industrial decision-maker perspective; decision-making process; barriers; drivers; energy benefits and non-energy benefits.

Bibliography

No texts suggested.

055642 Engineering and Cooperation for Development

(8 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

The interest of the international community for the multiple interconnections among energy, environment and society are fully recognized as it is the close link between energy and development. The Agenda 2030 and the 17 Sustainable Development Objectives provide some evidence: the world is increasingly interconnected and the social challenges are getting more and more complex and the call to multidisciplinary and multi-stakeholder action is recognized. Moreover, Goal 7 identifies energy availability as a necessary precondition for human and social promotion, as well as an instrumental right to fight poverty, in line with the broad concept of "development as freedom" defined by Amartya Sen.

Nevertheless, access to sufficient, affordable, efficient, reliable, safe and clean energy is not yet an opportunity for all. In developing countries, the problem is critical, but evidence has also risen in emerging countries and, more recently, even in developed countries. Innovative solutions and strategies to match the economic growth with the multidimensional targets of sustainability, including environmental preservation and social inclusion, need to be developed. The course aims at providing a general overview of the various aspects of cooperation and development analysed from a project, program and process-oriented perspective. The Project Cycle Management will be introduced as tool for appropriate design of cooperation Action.

The energy sector will be the mainstream of the applications. Therefore, more specifically for energy project, a planning methodology will be introduced where the final solution is designed identified and implemented to meet the local needs and exploit local resources and where technological choices (to be effective) depends on a number of local boundary conditions like local economic, environmental and cultural condition. The CESP has 6 phases: Priority identification, Diagnostic, Planning, Technical and Comprehensive Design and Expected Impact Evaluation.

The course aims to widen the vision of the students to the many implications that energy may have on development at global and local level. And to understand the many implications that this dichotomy may have on the engineering planning for effective and successful solutions. Some of the topics in the course will be managed with a blended classes approach making use of MOOC and other web resources. The project work is mostly an application of flipped classes.

Expected Learning Outcomes

The learning outcomes may be aggregated into four areas of knowledge:

1. The students will learn the foundation and the evolution of the main development models from the Marshal plan to the new paradigm of Sustainable Development; they will learn the trends of the energy situation in emerging countries with special reference to the African continent. The will learn the principles of energy planning and solution design by deepening the main renewable or hybrid technological solutions and will understand the basic

principle of Decision support Systems. Students will also understand the main implication among energy and development, energy and human right as well as their policy implication at national and regional scale.
2. The student will be able to apply the Project Cycle Management and the methodological approach to define appropriate energy solutions for rural and off grid areas by defining load curves and selecting technologies. They will be also able to draft business models and to adopt strategy for long term sustainability of the given solution. They will also be able to evaluate the expected impact of the energy solution onto the socio-economic asset of the target community.
3. the students will learn how to make choice and provide judgement, given a number of energy strategies for the same problem, they will be autonomous in identifying and defining a set of priority by adopting appropriate Decision support tools.
4. the students will learn how to prepare a project proposal according to standard methods (like PCM) and hot to present it, given a certain time and audience.

Topics Covered

Topic 1 History of cooperation and development models: From conflicts to cooperation. The phases of development cooperation: from the 50s to the present day. Colonialism and neo-colonialism. The theoretical foundations of cooperation and the evolution of development models. The Agenda 2030 and the 17 Development Goals. The Italian Law 125 on Cooperation and the New framework. In this part of the course we will make use of existing MOOC by Polimi and by other web sources with a blended classes approach.
Topic 2 Global energy scenarios and a focus on Africa: The world energy situation in accordance with the forecasts of WB and IEA: OECD economies, emerging economies and critical economies. The forecast scenarios. The main socio-economic indicators. The concept of development and poverty (UNDP) and the current estimates. The energy indicators for development (EISD - IAEA and EID - UNDP). Comparisons and time-varying extensive and intensive indicators. An Energy focus on Africa
Topic 3 Comprehensive Energy Solution Planning (CESP): Strategies and appropriate technologies for access to energy: The size of the problem of access to energy and sustainable energy in DCs. The Energy Situation in Africa. Priority definition: need analysis. Diagnostic: load curve definition and forecast and resources assessment. Planning: beyond centralized electrification, the case of off-grid system (conventional, alternative and hybrid), REs for Power production, Cookstove and biogas. Decision Support systems to select alternative. Technical and Comprehensive Design. Impact evaluation modelling. Open Source Tool for Microgrid optimization will be introduced (based on python).
Topic 4 The Project Cycle Management: PCM of the European Commission, as an instrument of cooperation. The identification phase (analysis phase): problem objective, stakeholder and strategy analysis. The formulation (planning) phase: the logical framework approach, the Gantt chart and the budget. Output, Outcome and impact indicators. SMART indicators and OVIs. The link between PCM and the Theory of Change.
Topic 5 Beyond technology: Energy, rights, economic models and policies: Energy and Rights: Resources and the common good, Ethics and Resources, Resources, and human rights. Energy and business models: funding and entrepreneurial approaches to energy access. Energy and policies: enabling policies for the dissemination of appropriate solutions. In this part of the course we will make use of co-organized seminars with external institutions partners of Polimi with a blended classes approach.

Bibliography

Main textbooks

Colombo, S. Bologna, D. Masera, Renewable Energy for Unleashing, Sustainable Development, Editore: Springer International Publishing Switzerland, Anno edition: 2014 Note: DOI:10.1007/978-3-319-00284-2_1

Monique Kremer, Peter van Lieshout and Robert Went, Doing Good or Doing Better development policies in a globalizing world, Editore: Amsterdam University Press, Anno edition: 2009 Note: Chapter 1,2,3,5

EU commission, Project Cycle Management, Anno edition: 2004

http://ec.europa.eu/europeaid/multimedia/publications/publications/manuals-tools/t101_en.htm

Transforming our World: the 2030 Agenda for Sustainable Development, Editore: Nazioni Unite, Anno edition: 2015

056620 Enterprise Transformation Projects
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

The following competences are suggested:
- P&L and Balance Sheet and basics of finance
- Investment analysis
- Operating Research and Optimization models
- Information Systems
- Cost management
- Applied Statistics

Learning Objectives

1. Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
2. Identify future trends, technologies and key methodologies in a specific domain (specialization streams)
3. Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

- Support students to combine their managerial learnings from previous courses and to face market, organization and technology challenges through real case studies.
- Guide students along cross-enterprise transformation projects, as example of consulting role in the real world.
- Familiarize with typical pillars of consulting support: M&A, post-merger integration, enterprise organization, HR management, operations management, ICT governance, data management.
- Explain the main topics of consulting industry: methodologies, tools, process, economics, and management
- Improve problem solving, holistic analysis and lateral thinking
- Blend theory with real cases studies

Topics Covered

- History of Management Consulting
- Consulting business model, players, key success factors, trend, economics and KPI, financials
- Consulting carrier, performance evaluation, incentive schemes
- M&A: goals and different models, categorization, process steps from scouting to closing, main actors (PE, Industrial, Advisors, lawyers), management incentives for deals

- Business planning for different strategic options, M&A, internationalization, new business, start up.
- Post-merger integration: day-one integration topics, synergies identification and implementation, new business models enabled by M&A, organization post deal, cultural integration
- Organizational models from traditional to agile, competencies evolution, employees' journeys, digital workplace
- Incentives plans from blue collars to managers
- Employer branding
- Process mapping and BPM: artificial Intelligence, workflow platforms, RPA and cognitive computing
- Predictive management
- Digital twins for process optimization
- Workforce Management
- Change Management new way: Early Adoption
- Enterprise Technology Architecture and functionalities: from Industry specific to new trends and evolution
- Data Centre Management (physical, virtual, cloud, private cloud, public cloud, Cloud strategy)
- ICT Governance: Organization Model, Contract management, Investment management and monitoring, System Development Life Cycle
- Data-driven culture, decision making and productivity
- Data management, value chain
- Data monetization
- Case studies on each of the subjects

Bibliography

David H. Maister, Managing the Professional Service Firm
Brent Adamson, Matthew Dixon and Nicholas Toman, The End of Solution Sales
Christensen, Alton, Rising, Waldeck, The New M&A Playbook (HBR March 2011)
Peter Dowling, "International Human Resource Management"
S. Armstrong, "The essential HR Handbook"
D. Kimball, "Cases in Human Resource Management"
Leandro Herrero, "Viral Change"; have a look also on his website "Daily Thoughts"
Pia-Maria Thoren, Agile People: A Radical Approach for HR & Managers
Daniel H. Pink, Drive: The Surprising Truth About What Motivates Us
S. Lowisz, Recruiting sucks, but it doesn't have to
Grieves e J. Vickers, «Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems (Excerpt)», ResearchGate, 2016.
E. Negri, L. Fumagalli, M. Macchi, «A Review of the Roles of Digital Twin in CPS-based Production Systems», Procedia Manufacturing, 2017.
Stark, S. Kind e S. Neumeyer, «Innovations in digital modelling for next generation manufacturing system design, » CIRP Annals, 2017.
Thomas H. Davenport, Jeanne G. Harris, Competing on Analytics: The New Science of Winning", 2017, HBR Press
Bern and Marr, Kogan Page, Data Strategy: How to Profit from a World of Big Data, Analytics and the Internet of Things,
Sunil Soares, The Chief Data Officer Handbook for Data Governance, Mc Press

097388 Entrepreneurial Finance

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Students are required to know the principles of industrial economics and the basic notions of finance

Learning Objectives

The course is meant to provide the frameworks, models and tools to understand the early stage financing of (innovative) privately-held entrepreneurial firms. The course will actively engage students in an experiential learning process. The instructors will provide theory and empirical evidence on entrepreneurial finance as well as the methodology commonly applied in this context. Guest speakers, such as venture capitals, business angels, crowdfunding platform managers, lawyers, and entrepreneurs will share their practical experience with the class. Teamwork activities are designed to involve students actively.
The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand the context, the functions, and the decisions of entrepreneurs and managers of financial intermediaries as regards early-stage financing of (innovative) privately-held entrepreneurial firms
- Identify the key methodologies to assess the value of (innovative) privately-held entrepreneurial firms
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to overcome the specific challenges of (innovative) privately-held entrepreneurial firms in accessing entrepreneurial finance
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

At the end of the course, the students will be able to:

- Understand the decisions of (innovative) privately-held entrepreneurial firms as regards access to early stage finance;
- Understand the decisions of managers of financial intermediaries as regards early-stage financing of (innovative) privately-held entrepreneurial firms;
- Use theory and empirical evidence on entrepreneurial finance to make better financial decisions;
- Identify the specific challenges for (innovative) privately-held entrepreneurial firms in accessing early-stage financing;
- Design appropriate strategies to alleviate the challenges for (innovative) privately-held entrepreneurial firms in accessing early-stage financing;

- Estimate the value of (innovative) privately-held entrepreneurial firms (valuation teamwork assignment);
- Apply theory and empirical evidence on entrepreneurial finance to real cases (case study teamwork assignment);
- Understand team working dynamics, develop leadership, negotiation skills, and conflict management ability (valuation teamwork assignment/ case study teamwork assignment);
- Develop communication skills and communicate the key concepts of their business model in a public context as well as in a written document (valuation teamwork assignment/ case study teamwork assignment).

Topics Covered

The course includes:

- Lecture sessions: they aim at illustrating, sharing and discussing models, conceptual frameworks, tools and empirical evidence.
- In-class case study discussions: they aim at making students apply the insights from theory and empirics to make financing decisions in real world situations. Students have to read case study materials in advance of the class sections.
- Teamwork evaluation assignment: it aims at making students learn how to evaluate an entrepreneurial firm.
- Testimonials: guest speakers (entrepreneurs, venture capitalists, business angels) invited to share their practical experience with the class.

Course detailed programme:

1. Introduction to entrepreneurial finance
2. Bootstrapping and debt financing
3. VC finance
4. Valuation of entrepreneurial firms
5. Exit strategies
6. Governmental VC
7. Crowdfunding & Business Angels
8. Accelerator & Incubators

Bibliography

No texts suggested.

057047 Entrepreneurship Economics
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Attendance of the Business and Industrial Economics course.

Learning Objectives

The course aims at providing students with a comprehensive understanding of key issues relating to the creation of new firms, the determinants of their performance, their impact on society, and the reasons and schemes for public support to entrepreneurship.
The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

- Develop awareness of the key determinants of new venture creation and performance and acquire knowledge necessary to make decisions concerning several crucial issues (entrepreneurial team creation, new venture organization, alliance formation and management, access to public financing, entry in an incubator) and considering the specificities of the new venture
- Develop the ability to discuss a business case in a group and present to an audience the results of this discussion

Topics Covered

- Introduction on entrepreneurship
- Entrepreneurial entry
    - The entrepreneur-specific factors: demographic characteristics, psychological traits, and motivations
    - The context of entrepreneurship: technological, industry, institutional, and local determinants of entrepreneurship
- The performance of new ventures and the impact on society
    - Survival: the liability of newness and smallness
    - Innovation: the role of new firms in innovation systems
    - Growth: growth theories, effects of new ventures on economic growth
- The determinants of new venture growth:
    - The entrepreneurial team: formation and evolution
    - Access to resources: hiring vs. team enlargement, alliances, incubation
    - Public support to Entrepreneurship
    - The organization of new ventures

- The heterogeneity of new ventures
    - Academic Entrepreneurship
    - Family Entrepreneurship
    - Entrepreneurship by minorities: female and ethnic entrepreneurship
- Wrap up and example of exam questions

During the course 10 business cases will be discussed by (groups of) students. The key learning goal is to improve the understanding of the lectures, by applying theory to practical cases or to add new elements to the issues discussed during the lectures.
Additional business cases will be discussed by course instructors during the lectures.

Bibliography

No texts suggested.

057068 Entrepreneurship Lab
(10 ECTS credits)

The course is offered in the:

Annual course (Sep – May)

Prerequisites

No pre-requisites required.

Learning Objectives

The course is conceived as an experiential based learning process, where students acquire frameworks, models and tools to develop their business mainly from the experience and advising of practitioners, i.e. entrepreneurs, venture capitalists, business angels, incubator/accelerator's managers, with whom the course is designed. The faculty will provide a core of preliminary concepts through frontal lectures on high-tech start-ups' creation and funding, after that the students will start to work in teams on their own business models, receiving inputs and feedbacks from practitioners, who participate as guest speakers, and throughout tutoring sessions. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand and design solutions, applying a scientific and engineering approach, in relation to the setting up of a new business, the design of its business model, and the identification of the proper funding channels
- Interact in a professional, effective and constructive way in teams and with external practitioners

Expected Learning Outcomes

At the end of the course, the students will be able to:

- Comprehend the functioning of the entrepreneurial ecosystem
- Understand what is a business model and its building blocks
- Identify the key challenges for the creation of high-tech start-ups and the funding mechanisms available, and understand when it is appropriate to use each of them, according to the specific start-up's industry, funding requirements and stage of the life cycle.

Through the project work, the students will also be able to:

- Test and validate the business model in the real world with potential customers
- Write an effective business proposal to ask for funding (i.e., to business angels, venture capitalist, incubator programs...)
- Work in teams
- Interact with practitioners of the financial sector
- Summarize and present the results achieved in the business proposal in front of potential investors clearly and convincingly.

Topics Covered

The course program includes the following topics:

- The creation of high-tech start-ups. Entrepreneurship in high-tech industries and high-tech start-ups in Italy and in the world
- The development of high-tech start-ups, and their performances, including the success factors
- The Business Model: what is a business model and how to fund it through equity capital, debt capital and public subsidies
- How to design the Business Model: the value proposition and business model testing; the use of the Business Model Canvas framework; organizational structure and management; market strategy and market positioning; competitors' analysis; how to protect competitive advantages; business model risk assessment
- The financing of high-tech start-ups: a series of guest speakers, including entrepreneurs, venture capitalists, business angels, incubator/accelerator's managers, will bring their direct experience through success stories regarding the funding (and creation) of high-tech start-ups (entrepreneurs) and explaining their decision-making and investment process (investors)
- How to design and perform an effective elevator pitch.

Bibliography

No texts suggested.

058059 ESG Principles in the Transition Economy
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

This course is designed to provide the students with a comprehensive set of knowledge and tools to understand the current worldwide Economy evolution in the light of Environmental, Social and Governance (ESG) principles.
First, a review of the macro-economic context, with a focus on the relevant policies and regulations driving the energy transition, will be introduced.
Afterwards, the evolution of ESG topics will be covered, focusing on companies acting in the most relevant sectors exposed to the transition. Sectors subjected to specific analysis are Banking, Automotive and its value chain, Steel and Energy. With a focus on these sectors, the course will provide insights with reference to:

- Strategy and business portfolio evolution;
- Sustainable finance;
- Corporate governance;
- New management performance metrics;
- Sustainable rating;
- Social sustainability initiatives;
- Financial and non-financial disclosures.

Lectures will be complemented by case histories presented by sectors leading companies, as well as talks with other relevant Market players (Banca d'Italia, Law and Audit Firms). Students will be required to play an active role by developing business cases on ESG Strategy/initiatives adopted by a selected set of leading Companies.

Expected Learning Outcomes

The main expected learning outcomes for students are:

- To understand the drivers of the current ESG market trend and to forecast further evolutions
- To evaluate the different ESG strategies implemented by leading companies in different sectors
- To learn how to govern a new ESG company's strategy from design to implementation and public disclosure

Topics Covered

The course is designed to introduce key concepts and tools for understanding and evaluating the evolution of energy companies' strategies in the ESG transition.
The course will benefit from a balanced mix of lectures, case histories presented by the industry senior management, talks with other relevant Market players and business cases presented by

students. Overall, interaction and active participation are key elements for a profound understanding of the covered topics.
The main topics covered during the course are:

- **Global energy scenarios and focus on international and national energy policies.**

Analysis of a) the world energy scenarios in accordance with the latest forecasts provided by IPCC, IEA and NGFS; b) evolution of energy supply and demand; c) focus and benchmarking of existing mechanisms implemented at supranational as well as national level (subsidies, carbon certificates trading, border tax)

- **Corporate strategies evolution**

Strategic impact of ESG principles over the most exposed Economy Sectors including Banking, Automotive and supply chain, Steel and Energy

- **Sustainable finance**

Sustainable finance and tools aiming at funding corporate activities connected to ESG principles. Climate related financial risk: the perspective of different parties (companies vs financing parties vs Regulator)

- **Corporate governance**

Introduction to the corporate governance basic principles and description of their very recent evolution induced by the ESG influence. Role of Active Shareholders and evolution of Directors' risk profile. Implications of ESG strategies on the management performance measurement.

- **Social strategies**

Overview of social sustainability practices in different Economy Sectors.

- **ESG rating**

Introduction to the global evolving context of ESG rating: consolidated standards and emerging trends

- **Disclosure**

Introduction to existing standards for climate-related financial and non-financial information disclosure.

Bibliography

No texts suggested.

057073 Estimation and Learning in Industrial Engineering
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Students are required to know the basic principles of probability and statistics and of linear systems theory, both for continuous-time and discrete-time systems.

Learning Objectives

The course presents methods and tools to enable students to formulate and solve model identification and data analysis problems and to design and implement state estimation systems, with specific reference to Aerospace Engineering. More precisely the following topics are studied: parameter estimation and output error model identification; fundamental data analysis problems; Bayesian estimation and learning; state estimation; black-box model identification; case studies in Aerospace Engineering.

Expected Learning Outcomes

Lectures and exercise sessions will allow students to:

- Acquire a more advanced knowledge of probability, statistics, estimation and learning theory.
- Formulate and solve model identification problems.
- Familiarise with data analysis problems such as principal component analysis and data classification.
- Design and implement state estimators for, e.g., aircraft and spacecraft attitude determination and navigation.

Topics Covered

Part 1: introduction to estimation and learning in aerospace:

- Overview of estimation and learning problems in aerospace: sensor calibration, parameter estimation, model identification, state estimation, navigation, fault detection, fault tolerant control
- Introduction to the theory of estimation and learning
- Introduction to model identification: problem statement; grey vs black box models; linear vs nonlinear models; the notions of structural and experimental identifiability
- The model identification process: from experiment design to model validation

Part 2: parameter estimation and output error model identification:

- Estimation theory: the maximum likelihood method
- Density estimation: Gaussian and Gaussian mixture models
- Least squares estimation; recursive least squares and least mean squares as supervised learning
- Time-domain output error identification of nonlinear state space models

- Time-domain and frequency-domain output error identification of linear state space models

Part 3: data analysis problems:

- Dimensionality reduction and principal component analysis
- Data classification and support vector machines

Part 4: Bayesian estimation and learning; state estimation:

- Estimation theory: introduction to Bayesian estimation and learning
- Optimal state estimation for linear systems: the Kalman filter.
- Time-domain equation error identification of linear state space models
- The Extended Kalman filter; overview of more general state estimation schemes

Part 5: black-box linear model identification:

- Problem statement: structure selection vs parameter estimation
- MIMO black-box modelling: predictor-based subspace identification

Part 6: case studies:

- Identification of control-oriented models for helicopter and multirotor flight mechanics.
- Attitude determination for aircraft and spacecraft: the Multiplicative Extended Kalman filter
- Experimental parameter and state estimation for the longitudinal dynamics of a multirotor UAV.

Bibliography

Main textbooks

Online course material http://www.aero.polimi.it/lovera Note: (in preparation)

Recommended materials

Sergio Bittanti, Model Identification and Data Analysis, Editore: John Wiley & Sons, Inc, Anno edition: 2019, ISBN: 9781119546405

Vladislav Klein and Eugene A. Morelli, Aircraft System Identification: Theory and Practice, Editore: AIAA, Anno edition: 2006 Note: 978-1563478321

Mark Tischler and Robert Rempel, Aircraft and Rotorcraft System Identification, Editore: AIAA, Anno edition: 2006, ISBN: 978-1563478376

M. P. Deisenroth, A.A. Faisal, C. S. Ong, Mathematics for Machine Learning, Anno edition: 2019 https://mml-book.com/

056233 Ethics for Technology B
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

This course deals with the application of ethical theories to problems created, aggravated or transformed by technology. This course aims at showing how the decision to develop a technology (meant at large), the processes of its design, development, management, control, and production are inherently moral. It is intended to give students a chance to reflect on the ethical, social, and cultural impact of technological applications. The course includes lectures by the instructor and invited lecturers; class participation will be expected, and students should apply what they learn through reading, lectures, and class discussions by looking at current events through an ethical lens.

Expected Learning Outcomes

Students will:

- Acquire a broad perspective on the ethical and social impacts and implications of science and technology;
- Be acquainted with normative ethics and normative argumentation;
- Learn how to recognize and analyse ethical and social aspects and issues inherent in some technological applications;
- Be able to understand how technical problems are inherently connected to a social dimension within a socio-technical perspective;
- Be able to use critical skills in clarifying and ethically analysing case-studies involving technology;
- Be able to apply ethical theories to problems created, aggravated or transformed by current technologies;
- Be able to explore and assess possibilities for solving or diminishing existing and emerging ethical and social problems;
- Be able to autonomously analyse the ethical issues of a technology and to develop a critical analysis on that;
- Be able to evaluate and select the appropriate knowledge in the effort of elaborating and justifying a philosophical argument on a topic autonomously selected;
- Learn to exercise and improve their skills in a critical writing;
- Learn to present in an effective way the results of their research, being able to justify their choices;
- Be better prepared to their future professional life in an ethically and socially responsible way;

- Be able to analyse problems through an ethical lens.

Topics Covered

The course will cover different topics both from a theoretical and a more practical point of view. We will start with a broad analysis of the concept of responsibility, in particular in an engineering perspective**,** and of normative ethics and its tools. We will discuss ethical questions in the design of technology with a focus on Design Ethics and its Social Ethics paradigm. Then ethics in IT**-**configured societies will be discussed and technology as the instrumentation of human action will be presented. Topics will include, for instance, the novel framework of Responsible Research and Innovation, Value**-**Sensitive design, the ethical aspects of technical risks, the relationship among sustainability, **e**thics and technology, information flow, privacy, and surveillance, digital order. Students will be supervised in class sessions in the development of the individual final essay in order to meet the standards required by scientific publications.

Bibliography

Main textbooks

Ibo van de Poel & Lambèr Royakkers, Ethics, Technology, and Engineering: An Introduction, Editore: Wiley-Blackwell, Anno edition: 2011

054136 Family Business

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

- Understand the distinctive strategic and managerial factors distinguishing the family business form of organization, and the impact of those factors on business performance
- Design solutions to strategic problems in family firms, applying a scientific and engineering approach based on rigorous models and frameworks
- Present strategic solutions in a family business organization in a professional, responsible, effective and constructive way, also working effectively within a group

Expected Learning Outcomes

At the successful completion of the course, students will:

- Be able to explain about the distinctive strategic and managerial implications of family influence on business
- Be able to use rigorous methods to assess the role of families for creating and sustaining competitive advantage and disadvantages
- Be able to articulate a family firms' vision, mission, values and goals
- Be able to predict and explain how family enterprises change and evolve over generations, and how they may succeed in disruptive environments
- Be able to systematically evaluate and choose between different strategies and routes of action in the family enterprise
- Be able to develop critical evaluations of the strengths and weaknesses of family enterprises in context

Topics Covered

Family-owned companies are highly prevalent across countries and industries, ranging from small to large, from local to multinational, from privately-held to publicly-traded family business groups. For long time, family companies have been the engine of the world's economic growth and development. Today, however, their traditional strengths are put into question by fast-changing global competition and technology disruptions. Moreover, recent research suggests that about 30% of family companies in Europe will undergo generational succession within the next 10 years. This new course will help you understand and implement the driving factors that help family companies succeed and thrive in the digital age. Whether you are part of a business family, or whether you intend to work with a family company as a non-family manager, consultant, investment banker, private banker or in other roles, you will gain important insights about how to leverage the strengths of family companies, address their inherent vulnerabilities, and sustain their competitive advantage over time.

Course contents include:

- The future of family firms in the 21st century: Definitions of family business; Types of family firms; Impact of demographic and societal changes on family firms.
- Designing effective governance for the family enterprise: Definition of corporate governance; Differences in corporate governance between family and non-family firms; The relationship between corporate governance and firm performance; Key constitutes of family and business governance.
- Succession planning and generational change: Internal and external succession options in family firms; Assessing the successor's fit and readiness; Planning and executing a succession plan.
- Professionalization: Professionalization defined; Internal and external dimensions of professionalization in family firms; The impact of professionalization on firm growth and performance.
- Managing resources, capabilities, and competitive (dis)advantages in family firms: The effect of family ownership and management on firm performance; Resources and liabilities of family firms; The success paradox; Assessing competitive advantage in family firms; Building sustainable competitive advantage in family firms.
- Strategy formulation and execution in family business: Family business strategy defined; Drivers of strategic decision making in family firms; The role of financial wealth and socio-emotional wealth considerations in family business strategy.
- Financing issues in family firms: Advantages and disadvantages of family business finance; Financing options in family firms; Financing growth in family firms; venture capital, private equity and public stock markets (IPO).
- Managing innovation in the family enterprise: Opportunities and challenges for family firm innovation; Innovation Through Tradition (ITT); Innovation and generational change in family firms.

Bibliography

Recommended materials

Thomas Zellweger, Managing the Family Business: Theory and Practice, Editore: Edward Elgar, ISBN: 9781783470709 https://www.e-elgar.com/shop/family-business-in-theory-and-practice

057093 Finance LAB
(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

The students are strongly encouraged to take the mandatory courses in the Finance stream.

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in equity capital raising, financial engineering and asset allocation;
- Develop new ideas and solutions in financial scenarios evolving over time, to be applied in a real-world setting;
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members.

Expected Learning Outcomes

- Understanding the processes and techniques of equity capital raising
- Knowledge of the basis of financial engineering and structuring complex financial products
- Understanding the asset allocation strategies and main indicators for the performance measurement
- Knowledge of the fintech and insurtech opportunities both as self-standing initiatives and as cooperation with incumbents
- Approaching practical issues in finance and learning to deliver solutions
- Demonstrating skills and capabilities to manage projects in a professional environment in the finance business

Topics Covered

The Finance Lab provides a unique opportunity to go in depth into the financial matters illustrated over the track, with an experimental approach and an integrated logic. In particular, the lab addresses both corporate finance and market finance themes, through frontal lectures, case studies, and business & portfolio simulation.
The topics introduced in the Finance Lab are:

- Equity capital raising
- Financial engineering and structured products
- Asset allocation
- Fintech and insurtech

During the laboratory, participants will have the opportunity to develop a project, in cooperation with banks, financial and industrial companies, where students could experience the real life of a career in finance. Topics introduced in the course are, among others, equity capital issues, advanced topics in derivatives, asset management and asset pricing.

Bibliography

No texts suggested.

097387 Financial Econometrics
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

The course is self-contained. However, some prior knowledge of statistical inference (estimation and testing theory) and of the linear regression model is preferable. Taking the course Introductory Econometrics in advance would be perfect, but it is not required.

Learning Objectives

This course will be useful to students who plan to take empirically oriented finance courses as well as students who want to get a solid understanding of the tools required to analyse and model financial asset prices and, more generally, economic time series related to any field of economics and management. The link between statistical models and their implementation is emphasized.
The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

With respect to the first learning goal, at the end of the course students will be able to:

- Understand the key aspects of statistical time series models, and how these models can be used to forecast economic variables and analyse their relationship
- Understand the differences between univariate and multivariate time series models
- Understand the importance of confidence intervals associated to point forecasts
- Understand the notion and relevance of stationarity in time series analysis
- Understand the key aspects of dynamic volatility models

With respect to the second learning goal, at the end of the course students will be able to:

- Select the appropriate time series model to apply in practical economic situations.
- Interpret the output of econometric packages implementing time series models
- Use time series models for forecasting economic and financial time series
- Use time series models to support economic decisions

Topics Covered

The course introduces students to financial econometrics, providing them with appropriate techniques for empirical investigation in finance. The emphasis will be on understanding and applying a set of econometric tools that are widely used by academics and practitioners working in quantitative areas such as risk management, investment management, and financial engineering (although most of the techniques are widely used also in empirical macro and monetary economics). After a quick review of the multiple linear regression model, the course will illustrate univariate and multivariate models for time series analysis and forecasting. The analysis of non-stationary time series will be discussed, illustrating the theoretical and empirical relevance of the notion of integration and cointegration. The course also covers dynamic models for volatility analysis (ARCH and GARCH models) and one topic, possibly varied from year to year (event studies, Markov switching models, Factor models, ...). Providing the students with the ability to use the models is one of the goals: to this aim, problem sets with both analytical and computer-exercise components will be a relevant part of the course.

Main topics:

- Refresher on the linear multiple regression model: estimation through Ordinary Least Squares, checking assumptions (functional form, multicollinearity, heteroskedasticity, autocorrelation, non-normality)
- Univariate analysis of time series: Stochastic processes and their properties. AR, MA and ARMA models. Analysis of trend, cycle and seasonality.
- Multivariate analysis of time series: ARX models and VAR models
- Analysis of nonstationary univariate and multivariate time series: integration and cointegration
- Models for the analysis of volatility: ARCH and GARCH models.
- One of the following topics: Event studies, econometric aspects of the CAPM, econometrics of the efficient frontier, econometrics of derivatives, analysis of ultra-high frequency financial data, long memory processes, Markov switching models, ... The topic will be chosen at the beginning of the course. Students willing to deepen autonomously, for some reason, a different topic instead of the chosen one, may propose it.

Bibliography

Main textbooks

Chris Brooks, Introductory Econometrics for Finance, Editore: Cambridge University Press, Anno edition: 2014 ISBN: 9781107661455
http://www.cambridge.org/features/economics/brooks/
Note: Chapters 1 to 8

055645 Financial Markets and Institutions

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

The course aims at allowing students to:

- Understand roles and functions of financial markets and how they support the real economy;
- Know what are the major activities of banks and other financial institutions;
- Share the impact coming from digital innovation and sustainability on financial markets and institutions.

Expected Learning Outcomes

At the end of the course, students will know:

- How financial systems and financial intermediaries operate;
- What are the main figures of banks and financial institutions and how they are related to the businesses;
- Main trends related to the financial and digital innovation and sustainability.

Topics Covered

The course focuses on financial markets and institutions. In particular, it concentrates on the features, the objectives, the role and the typologies of financial markets and of the different categories of financial intermediaries and institutions. A major attention will be dedicated to banks. Moreover, some lectures will provide insights about the banks P&L, their supervision and regulation and the Banking Union. The course will also focus on banks corporate governance. All the items will include a description of how the digital transformation and the fintech as well as sustainability are playing a major role on financial markets. In details, the lectures of the course will be about:

- Financial and economic systems
- Financial markets and institutions
- Fintech and digital transformation
- The theory of financial intermediation
- Banks
- Bank supervision, prudential regulation and the Banking Union
- Banks P&L, economic and financial equilibrium, asset liability management
- Banks risk management: classification of risks in banking. RAF and IXAAP
- Corporate governance and sustainability
- Securities: bonds, equity, derivatives, forex
- Asset management and ESG Investing

Bibliography

No texts suggested.

097355 Financial Risk Management
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Statistics.

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and financial environment and the impact of those factors on business performance;
- Identify trends, technologies and key methodologies in a specific domain (specialization streams);
- Develop new ideas and solutions in business and financial scenarios evolving over time.

Expected Learning Outcomes

- Indicate the importance of risk management practices inside financial institutions and the drivers that made this topic particularly relevant; understand the role of risk management in preventing issues and difficulties coming from credit, market, liquidity and operational risks. Discuss the importance of the relation between risk and capital. Illustrate a taxonomy of risks and possible strategies to manage them. Express the causes and effects of the last decade's financial crisis. Show the main regulatory frameworks and the rationale behind them. Discuss the difference between regulatory capital and economic capital.
- Summarize the main financial instruments and the principles of CAPM; explain the key methodologies applied in risk management, in particular VaR, ES, Credimetrics, Credit Risk Plus, Vasicek's model and all the tools suggested by the regulator in Basel regulation for risk assessment, from the concept of Risk Weighted Assets to LCR and NSFR. Illustrate the main instruments for the estimate of default probabilities.
- Illustrate the emerging new business models of the financial institutions and relate each one of them to the risk management activity. Evaluate the connections among risks and business models, especially during the digital transformation phase.

Topics Covered

The course focuses on financial risks topics. Financial risks have become in the last decade among the most important value drivers. It's a key issue for a company and for a financial institution to face them in order to create value and to optimize capital allocation in coherency with the expected results and risks. In particular, it concentrates on the main financial risks. For each one of them the course focuses on the measurement and on the main solutions and techniques in order to manage them. At the end of the course, students will be able to understand in detail most of the current debate on financial institutions through a better understanding of the Basel regulation, its requirements and its main outcomes and implications.

Contents description

- Financial Risk Management (FRM): Process and Main areas
- FRM and Digital Transformation
- Risk and Return
- Mutual funds and Hedge funds
- Trading in financial markets
- The financial crisis
- Basel I, II and III
- Credit risk and Probability of Default
- Operational risk
- Liquidity risk
- VaR
- Scenario analysis and stress testing
- Economic capital

Organizational issues

The contents are provided through class lectures, which consist in both theoretical lessons and exercises. Lectures have a strong correspondence with the suggested textbook. Students should attend class regularly and actively participate, contributing to class learning and discussion. Some sessions will be given through practitioners coming from the most important and highly-reputed financial risk management departments.

Bibliography

Main textbooks

Hull, J., Risk Management and Financial Institutions**,** Editore: Wiley, ISBN: 978-1118955949

057029 Financing Complex Projects

(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Student must have a basic knowledge of corporate finance concepts (i.e. NPV, cash flows, IRR, restatement of balance sheet and P&L).

Learning Objectives

The aim of the course is the analysis of the instruments to finance complex projects in the infrastructure sector (i.e. energy, transport, real estate, healthcare). The course will introduce the role of infrastructure investments as driver of growth and will cover the structure and the characteristics of the structured finance transactions, in terms of financial structure, technical characteristics, players involved, risk analysis, capital budgeting and valuation. In the course, students will analyse the specific characteristics of instruments to finance infrastructure and to cover risks during the construction and operating phases. During the course, guest speakers will share their practical experience on infrastructure and project finance projects.

Expected Learning Outcomes

At the end of the course, students will be able to analyse financial characteristics of complex projects, to identify key elements of the deal and identify proper solutions for deal structuring with financial prospective.

Topics Covered

- Introduction: the role of complex projects as alternative investment asset. Taxonomy of project and infrastructure finance. Key features of infrastructure assets
- Structure and characteristics of project finance deals
- The role of the parties involved in complex project financing: banks, sponsors, syndication
- The risk profile of complex projects: identification and mapping and instruments to manage risks
- Capital budgeting of infrastructure
- Financial valuation for project finance

Bibliography

Main textbooks

Slides and case studies available on Beep

S. Gatti, Project Finance in Theory and Practice, Editore: Academic Press, Anno edition: 2018

Note: III Edition

051113 Fundamentals of Energy Technologies

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Basic knowledge of mathematics, chemistry and physics.

Learning Objectives

The course aims to provide the students with the theoretical knowledge of physics and engineering to understand, model and design different technologies, ranging from traditional energy conversion systems to electrochemical devices, like batteries and fuel cells, that occupy an increasingly important role in energy conversion and in the storage sector. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in energy technologies and the impact of those factors on energy technologies development;
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in energy technologies.

Expected Learning Outcomes

The main expected learning outcomes are the following:

- Identify the physical processes regulating and limiting the operation of conventional and electrochemical energy technologies
- Point out requirements of energy technologies in function of different applications
- Identify and understand the main technological issues regarding electrochemical devices and their impact on technology development and costs
- Determine performance and efficiency of conventional and electrochemical energy technologies in different operating conditions
- Calculate efficiency losses occurring in physical processes of energy technologies and assess room for improvement
- Design energy technologies for both stationary and automotive applications, focusing on the trade-off between performance and cost

Topics Covered

The course provides the basis of thermodynamics to deal with the design criteria of different energy technologies. Then, after a technological assessment, the features of some traditional and electrochemical conversion and storage systems for automotive and stationary applications are analysed in depth, focusing on performance, efficiency, technological issues and off-design conditions.

Traditional energy conversion systems

Physics:

- Review of the 1st and 2nd principle of thermodynamics.

- Introduction to exergy and exergy analysis.
- Review of heat and mass transfer in heat exchangers.

Technologies:

- Joule-Brayton and Rankine cycles for stationary applications: operating principle, efficiency, technological issues and limits, off-design conditions, combined cycle.
- Otto and Diesel cycles for automotive applications: operating principle, efficiency, technological issues and limits, off-design conditions, market analysis.
- Introduction to renewable energy sources (hydro, solar, windmill) and their effect on worldwide energy consumption, electricity price and electric grid stability, focus on Italian scenario.

Electrochemical conversion and storage systems

Physics:

- Working principles of batteries and fuel cells.
- Thermodynamics and exergy analysis of electrochemical cells.
- Mass transport phenomena and kinetics of electrochemical cells.

Technologies:

- Historical overview of electrochemical devices, state of art of electrochemical energy conversion and storage technology for automotive, stationary and portable applications.
- Batteries with aqueous and non-aqueous electrolyte: general features, efficiency, charging and discharging issues, technological limits, lithium ion battery, flow batteries.
- Water electrolyser for energy storage: general features, efficiency, technological issues and limits, off-design conditions.
- Polymer electrolyte fuel cell for stationary and automotive applications: general features, efficiency, technological issues and limits, off-design conditions.

Bibliography

Recommended materials

Michael J. Moran, Howard N. Shapiro, Fundamentals of Engineering Thermodynamics, Editore: Wiley & Sons

095917 Fundamentals of Oil and Gas Engineering
(8 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No prerequisites required.

Learning Objectives

Access to sustainable, affordable water, energy and food are some of the major technological challenges of the 21st century. How do we manage precious and scarce water resources, while preventing pollution? How do we extract the most of our remaining supplies of conventional oil and gas? How can we extract, safely, shale gas and oil? Can we collect and store carbon dioxide in the subsurface to prevent atmospheric emissions and help avoid dangerous climate change? Can we manage to provide sufficient energy for a growing world's population with an aspiration for improved prosperity? An understanding of these challenges involves multiphase flow in porous media – the flow of water, oil and gas with associated pollutants – underground in geological formations.
The subject of multiphase flow in porous media is undergoing a revolution, not just as a result of its many important applications, but because of developments in our quantitative understanding of how fluids are arranged and move, combined with the ability to image fluids at the micron-scale inside rocks.
This course will apply concepts of multiphase flow in porous media to understand and design recovery from oil and gas reservoirs. This is one of the major challenges referred to above – at present we recover only around one third of the oil from fields we have discovered. How can we improve this to the 50-60% now achievable with the best engineering methods, and beyond?
This course will describe how different methods can be used to:

- Assess the development potential of oil and gas reservoirs;
- Identify principal displacement mechanisms controlling performance;
- Predict recovery and oil-in-place;
- Understand reservoir simulation methods. It is assumed that you already know about hydrocarbon phase behavior, reservoir simulation and the principal reservoir drive mechanisms. You will also need to know Darcy's law and the meaning of relative permeability and fractional flow, although these are described again in these notes. The emphasis will be on learning fundamentals with some time taken to cover basic concepts. I will not repeat details that are well covered in other textbooks, or which are not strictly relevant to this course. Furthermore, these notes will not illustrate the concepts with field examples: this is better left to project work or indeed industrial experience. This is not a manual for reservoir engineers, but a teaching tool to establish the fundamentals.

Expected Learning Outcomes

The main expected learning outcomes for each of the following capabilities are:

- Understand: the students will learn how the automation and digital technologies (i.e. Industry 4.0) are affecting the future manufacturing systems, both in the process industry as well as in the discrete manufacturing systems;
- Identify: the students will learn how to select (i.e. identify) the best technology and the best application scenario;
- Design: designing a manufacturing system is a complex process which requires to deal with the hard, soft and organizational dimensions of the design of the system. Quantitative and qualitative techniques will be explained. The impact evaluation will also be assessed in order to give students the know-how on how to understand the impact of their decisions.

Topics Covered

1. Introduction to the oil industry – its history and stages of production.
2. Societal context: population, global production and climate change.
3. Oil terminology and definitions, recovery factor and reservoir pressure regimes.
4. Material balance for oil and gas reservoirs, including analysis for natural water drives, solution gas drives, compaction drives and gas cap expansion.
5. Decline curve analysis, including harmonic and hyperbolic decline.
6. Darcy's law and dispersive transport.
7. Capillary pressure and the configuration of multiple fluids in the pore space.
8. Multiphase flow and relative permeability.
9. Displacement mechanisms including the Buckley-Leverett and Welge analysis for analytic oil recovery calculations.
10. Analytic solutions for imbibition.

Bibliography

Recommended materials

1. *Fundamentals of Reservoir Engineering*, L. P. Dake, Elsevier, (1991), ISBN 0-444-41830-X.
   This is the best book for the whole class and describes material balance, phase behaviour and Buckley-Leverett analysis.
2. *Petroleum Engineering Principles and Practice*, J. S. Archer and C. G. Wall, Graham and Trotman, (1986), ISBN 0-86010-665-9.
   This book was co-authored by John Archer, a Professor of Reservoir Engineering at Imperial who later was Vice-Chancellor of Heriot-Watt University.
3. *Applied Petroleum Engineering*, B. C. Craft and M. F. Hawkins, Prentice Hall, (1991), ISBN 0-13-039884-5.
   Excellent on material balance, but has a very practical focus with little explanation of the methods used.
4. *Waterflooding*, G. P. Willhite, Society of Petroleum Engineers, (1986), ISBN 1-55563-005-7.
   Another good textbook, but does not cover all the material in this class.
5. *The Reservoir Engineering Aspects of Waterflooding*, F. F. Craig, Jr., Society of Petroleum Engineers, (1971), ISBN 0-89520-202-6.
6. *Enhanced Oil Recovery*, L. W. Lake, Prentice Hall, Englewood Cliffs, (1989) 500 pages.

This is a truly excellent and detailed book – one of the very best in petroleum engineering. It does cover much of the material in these notes, but – for improved oil recovery – at a level of detail which is much greater than we have time for in this course.

7. *Groundwater*, R. A. Freeze and J. A. Cherry, Prentice Hall, Inc, Englewood Cliffs, (1979). This is a standard hydrology text, but does not cover multiphase flow, and does not have a focus on oil recovery.
8. *Porous Media: Fluid Transport and Pore Structure*, F. A. L. Dullien, Academic Press, San Diego, 2nd Edition, (1992). This is a fabulous research reference book that covers much of the scientific material in these notes and contains a lot of experimentally-based physical insight into multiphase flow.
9. *Dynamics of Fluids in Porous Media*, J. Bear, Dover Publications, Inc, New York, (1972). A classic in its field – indeed it help establish the subject of flow in porous media as a discipline. Very mathematical, but contains a lot of useful information.
10. *Capillary and Wetting Phenomena: Drops, Bubbles, Pearls, Waves*, P-G de Gennes, F. Brochard-Wyart and D. Quéré, Springer (2002). The first author is the charismatic, and now sadly deceased, physics Nobel Prize winner, Pierre-Giles de Gennes. A fascinating book, packed full of interesting analysis, but not directly relevant to flow in porous media. Acquire a French accent, light up a Gaulois, wave your hands and voilà – brilliant insights into physics!
11. *Multiphase flow in permeable media: a pore-scale perspective*, M J Blunt, Cambridge University Press (2017). This is my own recently-published book that covers the material on multiphase flow in these notes in more detail.

094785 Fundamentals of Signals and Transmission
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No prerequisites required.

Learning Objectives

The course presents a comprehensive overview about the fundamentals of signals and transmission systems, necessary as prerequisite for advanced coursework in the study of communications. The course provides the students the instruments to analyze deterministic signals and random processes, with a thorough treatment of Fourier analysis and of noise in communication systems. Moreover, baseband and band-pass communications are presented with practical examples and real-world communications problems. Each topic is treated both theoretically and practically. The ability to apply the gained knowledge will be continuously verified through recurring class exercises and homework. Selected topics are associated with some simulative activities. The students are supported by a tutor in their understanding.

Expected Learning Outcomes

The lectures and exercise sessions of the course will provide a solid background, allowing the students to understand the basis of signals and transmission and to face additional coursework in the study of communications and signal processing.

The students will be able to apply the principles and tools of signals and systems acquired during the course to all of them, although the signals and systems are naturally different in their physical origin and application, arising across different fields (sound, image, data, optics, radio). The students will be able to clearly see connections among theoretical concepts and recognize how to apply them to the field of telecommunication engineering.

The students will learn how to present the course topics with a specialized vocabulary, necessary for the following advanced coursework in the study of communications.

Topics Covered

1. Fourier analysis. Deterministic signals. Linear time-invariant systems. Inverse relationship between time and frequency. Bandwidth. Sampling theorem. Impulse response and frequency response. Filters. Complex baseband representation of band-pass signals. Phase and group delay.
2. Fundamentals of probability and random processes. Stochastic process stationarity. Autocorrelation and cross-correlation function. Ergodicity. Power spectral density. Transmission of a random process through a linear time-invariant system. Gaussian processes. The additive white Gaussian noise in communication systems.
3. Baseband transmission of digital signals: matched filter, intersymbol interference, Nyquist criterion, probability of error due to noise, multilevel transmission.

4. Band-pass transmission of digital signals: band-pass transmission model, coherent detection, examples of QAM and PSK, comparison of noise performance.

Bibliography

Main textbooks

Simon Haykin, Michael Moher, **Communication Systems - Fifth Edition**, Editore: Wiley, ISBN: 978-0-470-16996-4

058355 Game Theory

(5 ECTS credits)

The course is offered in the:

First Half-Semester (Sep – Oct)

Prerequisites

Some mathematical analysis and linear algebra and the basics of probability.

Learning Objectives

The course is aimed at illustrating the fundamentals of the mathematical theory of interactions between agents. It starts with the discussion of the main assumptions underlying the theory, and it continues by considering the possible description of the games: the extensive and the strategic form. Both the cooperative and non-cooperative theory will be considered. The goal is to explain how rationality can explain and/or predict and/or suggest the behavior of interacting agents. This is not limited to human being, it can also be applied to animals, networks of computers and so on. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance.
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment.

Expected Learning Outcomes

Knowledge and understanding

1) To know the fundamentals of interactive decision theory.
2) To know some of the proofs of fundamental theorems in non-cooperative game theory.
3) To know some of the proofs of fundamental theorems in cooperative game theory.

Ability in applying knowledge and understanding

1) To be able to modelized simple interactive situations as games.
2) To be able to state and explain the proofs of fundamental theorems in game theory.
3) To solve exercises.

Making judgements

1) To be able to state translate a problem in a game and analyse it.

Communication skills

1) To be able to explain and illustrate (in written form) a definition, the text of a theorem, its proof.

Topics Covered

1) The main assumptions of the theory. Main differences between the decision theory and the interactive decision theory.

2) The Nash non-cooperative model, Nash equilibrium and existence of (mixed) equilibria in finite games. Examples. Potential games, how to find a potential. Examples: congestion games, routing games, network games, location games. Price of stability and of anarchy. Zero sum games. Games in extensive form. Games with perfect information, backward induction. From the extensive to the strategic form. Combinatorial games.
3) Cooperative games, definitions, examples. Core, nucleolus, the Shapley value and power indices.
4) Problems of matching.
5) Mechanism design
6) Basic of Social choice and Arrow's theorem.
7) The bargaining problem: the Nash and the Rosenthal approaches.

The last topics will be proposed if time suffices.

Bibliography

Recommended materials

M. Maschler, E. Solan, S. Zamir, Game theory, Editore: Cambridge University Press, Anno edition: 2013

057020 Global Environmental Challenges
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

A keen interest in environmental and energy issues. A strong background in economics and data science/econometrics. Knowledge of statistical/mathematical programming and software (i.e. Stata, R, MATLAB, Python) is an absolute requirement. The attendance of the course in Applied Statistics is highly recommended. The course is methodologically advanced and very quantitative. Willingness to work in teams and being pro-active is also required.

Learning Objectives

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify future trends, technologies and key methodologies in a specific domain (specialization streams)

Expected Learning Outcomes

The main objective of this course it to provide a quantitative evaluation of the biggest environmental challenges, and of their repercussions on the functioning of economic and human systems. A particular focus will be given to climate change, one of the greatest risks faced by our societies and one which will severely influence economic and business activity around the world. The course will use advanced methodologies from econometrics and data science to pin down the causal relations between global environmental challenges and socio-economic outcomes. The geographical focus will be global, analysing both industrialized economies as well as developing countries, which face different repercussions of environmental degradation. At the end of the course each student should be able to:

- Understand global environmental challenges and their impact on economic outcomes
- Know the implications of environmental issues on economic growth, business, welfare, inequality, and poverty
- Illustrate possible solutions to environmental problems at different levels (international, national, organization, citizen)
- Understand the difference between correlation and causality and recognize strengths and limits of different approaches for impact evaluation
- Apply empirical analysis to test the impacts of environmental problems mitigation strategies on relevant outcomes
- Search and connect different data sources, visualize key variables and design impact evaluation analysis

Topics Covered

The course will be structured around three main content parts, complemented with one methodological part:

1. The science of global environmental challenges. What are the biggest environmental challenges, above all climate change? What does science tell us about their drivers and expected impacts? Environmental challenges, stylized facts (trends and physical impacts):
    - Energy transition and access to energy
    - Air pollution
    - Climate change
    - Deforestation/biodiversity
2. Economic impacts of global environmental challenges. How do the physical impacts identified in part 1 translate into economics, business and social repercussions? What are the repercussions for economic growth, inequality, and poverty?
3. Solutions to global environmental challenges. What can governments, citizens and businesses do to mitigate the risks of crossing planetary boundaries? Which policy tools are needed to solve them?

The contents in parts 2 and 3 related to the impacts will be presented through academic papers and case studies published in high level economic and scientific journals.

A particular emphasis will be devoted to the empirical methods to identify causal impacts. We will discuss and apply both experimental (i.e. randomized controlled trials) and non-experimental methods (difference-in-differences, panel data, Regression Discontinuity Design, instrumental variables, propensity score matching) for impact evaluation. We will also discuss how big data from smart sensors, satellite observations, etc. can help identify the causes of global environmental change and help mitigate their impacts.

Bibliography

No textbooks suggested.

057012 Global Supply Chain Planning

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

The course fits into the concentration in Supply Chain (SC) Management of the overall curriculum in Management Engineering, and it contributes to some general learning goals. The course focuses on developing the following capabilities.

- To identify trends, technologies and key methodologies in the realm of SC Planning.
- To design approaches, tools and methodologies grounded on a scientific and engineering-based approach (analysis, learning, reasoning, and modeling skills coming from a solid and rigorous multidisciplinary background) to face SC planning problems and opportunities in service-related and industrial environments.
- To interact in a professional, responsible, effective and constructive way in a working environment, motivating also team members.

Expected Learning Outcomes

Upon completion of this course, the students are expected to demonstrate ability:

- To identify trends, by assessing the impact of planning activities over SC decisions, in the light of the increasingly growing need to deliver bold SC plans to react to a continuously changing competitive scenario;
- To design and develop effective global SC plans aligned to corporate strategic plans and critical success factors of the addressed business area. The students will be able to contribute to the main SC decisions ranging from SC configuration to short-term delivery plans for the different SC partners.
- To successfully interact with professionals from different disciplines and various backgrounds, by identifying the main planning issues and outlining the cause-effect relationships that drive SC performance.

Topics Covered

Amazon, Apple, McDonald's, Procter and Gamble (P&G), Unilever. What do they have in common? Most of them share outstanding places in Fortune 500 ranking, and all of them – according to Gartner[1]– represent the Masters category, which recognizes sustained SC excellence. The Masters continue to demonstrate advanced lessons for the SC community, and they highlight the accomplishments and capabilities of long-term SC leadership. While the wave of Covid pandemic was sweeping the world, SC disruptions and resilience gained attention in daily news. However, behind resilience and agility – to navigate turmoil effectively and successfully – SC Masters have been restructuring their organizations, transforming business models and redefining markets by blending well-established capabilities with emerging innovations. In the

[1] https://www.gartner.com/en/supply-chain/research/supply-chain-top-25

end, SC masters have succeeded in reshaping their own SCs through tremendously effective planning initiatives.

How should we care about SC planning?

In a search for competitive differential advantage, many managers of world–class organizations around the globe have come to realize that differentiating on processes is more sustainable than differentiating on products. Indeed, SC planning is the forward-looking process of coordinating assets to optimize the delivery of goods, services and information from supplier to customer, balancing supply and demand[2]. SC planning looks after current processes – including the ones originated in pure service industries – and determine methods for orchestrating the execution flow, the information flow and the financial flow in SCs.

Who are SC planners?

SC planners have the ability to look at the whole SC from upstream to downstream with both short- and long-term mindset. They also troubleshoot breakdowns along the SC and respond fluidly to unexpected events. We now live in the age of the digital SC, which makes it easier than ever before to understand the intricacies of SCs. SC planners are tech-savvy and they feel comfortable working alongside the world of "machines": they combine technical and business knowledge (for example the ability to handle forecasting and logistics) with collaboration and communication skills in writing and verbal conversation with a wide range of characters from dock workers to high-level executives and business owners. SC planners do not work in a silo and they do not wait for someone else to do what needs to be done. They are proactive, and they bring out the same drive in others. In the end, SC planners are leaders in the seminal meaning of people who cause others to want to travel with them[3]: they show the way to themselves, to others and to teams.

How should we train the SC planners of the future?

When it comes to SC planning, CEOs typically feel in the dark and they take a back seat, thus overlooking that if an organization really nails its SC planning, it can react to disruptions before they even happen, and quickly transform strategy into execution. We must train SC planners in such a way that they are able to steer their organizations to respond more quickly to market development, and they can lead their organizations on a journey toward prolonged success by forging a greater synergy with their CEOs.

There are at least three major topics SC planners should make their CEOs aware of, before dipping their toes into SC planning: (i) whether company's SC has been consciously established and improved through a decision-making process, or it has merely evolved, which reveals that probably SC configuration has not received enough attention and your logistics managers do not know why warehouses are located where they are; (ii) whether business and SC strategies are misaligned, as SC plans have much more to do with customers and service than suppliers and cost, which means that a growth business strategy and an aggressive cost-cutting SC strategy do not match; (iii) whether some customers are over-serviced – and then less profitable – as service levels are based on perceived customer needs, but you failed to check whether the reality matches that perception.

What SC planners should bring in their toolboxes?

Some widespread gossip whispers that SC planners are ideal positions for analytical nerds who spend their idle time at work playing Tetris and who would rather solve a Rubik's cube at the weekend than do anything else. On the other hand, the SC planners of the future are outgoing

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[2] https://www.gartner.com/en/information-technology/glossary/scp-supply-chain-planning

[3] The leadership role is more about the destination, vision, engagement, emotion. To capture a glimpse of leadership, try: https://www.youtube.com/watch?v=pxBQLFLei70 (2014 commencement speech at UT Austin). A footage is available also with subtitles (and ads): https://www.youtube.com/watch?v=TBuIGBCF9jc

leaders with outstanding ability to steer effective SC designs: they keep SC plans aligned to business plans, and they improve service levels while reducing costs at once. Hence, a typical SC planning toolbox include: Sales and Operations Planning (S&OP), Collaborative Planning Forecasting and Replenishment (CPFR), Vendor–Managed Inventory (VMI), Direct Delivery Systems (DDS), Available and Capable to Promise (ATP/CTP), multi-plant capacity planning, demand and inventory planning and factory planning.

Classes have been arranged into 13 – 14 main sessions with a typical format of 3 – 4 hours in a row once or twice a week. The course syllabus has been built around the best path we should set out to properly train the SC planners of the future.

Sessions L1 to L8 are related to lectures and each of them matches with several case studies, to be practiced in the corresponding session in a flipped mode fashion. Case-studies play a pivotal role in achieving a relevant portion of Learning Objectives[4] and they will be corroborated by some guest speeches of industrial directors and planners.

After the introductory session (L1) devoted to planning and strategy, Sessions L2-L5 refer to the remaining four major areas involved in the SCOR model (Source, Make, Deliver and Return). Then, Session L6 is related to emerging trends and recent advances in SC planning and it intends also to introduce some good planning practices and IT tools popular among relevant organizations. Session L7 typically takes place toward the end of the course. Students – arranged in teams – are required to defend the case study they conceived and wrote over the course (their 'own' case) related to either a real-life company or a new-born one (start-up or new venture).

Sessions G1-G5 are devoted to the Blue Connection, a web-based business simulation where participants – arranged in teams of four – get acquainted with the opportunities and challenges of adopting circular SC strategic plans. Students will be confronted with various real-life, real-time dilemmas that require cross-functional understanding, collaboration, and leadership.

Finally, sessions T1 and T2 include additional practice respectively on sessions L1-L3 and L4-L7, and they can be graded on-demand as Mid-term exam and Early-bird exam.

Bibliography

Main textbooks

- *Jacobs, F.R., Chase, R. B.*, 2018, "Operations and SC Management", McGraw-Hill.
- *Cigolini, R., Franceschetto, S.*, 2021, "Cases in SC Management", Mondadori

Additional textbooks (in alphabetical order)

- *Christopher, M.*, 2016, "Logistics and SC management", Pearson Education.
- *Correa, H.G.*, 2014, "Global SC management", Atlas
- *Gattorna, J., Ellis, D.*, 2019, "Transforming supply chains: realign your business to better serve customers in a disruptive world", FT Series
- *Harrison, A., Van Hoek, R.*, 2014, "Logistics management and strategy: competing through the SC", Pearson
- *Ivanov, D., Tsipoulanidis, A., Schoenberger, J.*, 2019, "Global SC and operations management", Springer

[4] To see how a typical case-based session should look like, try: https://www.youtube.com/watch?v=p7iwXvBnbIE.
The instructor's standpoint is well highlighted here: https://www.youtube.com/watch?v=eA5R41F7d9Q&t=44s

- *Johnsen, T., Howard, M., Miemczyk, J.*, 2014, “Purchasing and SC management. A sustainability perspective”, Routledge.
- *Mangan J., Lalwani, C.*, 2016, “Logistics and SC integration”, Wiley
- *Rushton, A., Oxley, J., Croucher, P.*, 2017, “Handbook of logistics and distribution management: understanding the SC”, Kogan
- *Sadler I.*, 2007, “Logistics and SC integration”, Sage
- *Shah, J.*, 2016, “SC management: text and cases”, Pearson
- *Shapiro, J.F.*, 2007, “Modelling the SC”, Brooks/Cole, Cengage Learning.
- *Stadtler, H., Kilger, C.*, 2005, “SC management and advanced planning”, Springer
- *Waters, D., Rinsler, S.*, 2014, “Global logistics: new directions in SC management”, Kogan

Videos

The next few videos may represent a thoughtful introduction to some key topics of the course:

- SC Planning @ Starbucks: https://www.youtube.com/watch?v=ElYNhGbOTOQ
- SC planning via SCOR model: https://www.youtube.com/watch?v=VrX2Qf0OT2M
- SC planning via SCOR again: https://www.youtube.com/watch?v=sL0vKtpwWP0
- What supply planning is: https://www.youtube.com/watch?v=4iI6La7-U2o
- Integrated SC Planning: https://www.youtube.com/watch?v=fM4xKfLZhFI
- A digital SC for the future: https://www.youtube.com/watch?v=HKnpiDiCe2s

Then, just for the sake of warming you up before starting, you might as well take a glance here.

1. A look around the notion of SCs & SC Management:
    - https://www.youtube.com/watch?v=Mi1QBxVjZAw&t=11s
    - https://www.youtube.com/watch?v=lZPO5RclZEo&t=2s
    - https://www.youtube.com/watch?v=4-QU7WiVxh8
    - https://www.youtube.com/watch?v=ZuQ200JAViA&list=PLCD3E338A3E58E906&index=7
    - https://www.youtube.com/watch?v=YbM_LydRlnM
    - SC strategies & the service sector: https://www.youtube.com/watch?v=mPkgkwb08GU
    - SC transformation @Intel: https://www.youtube.com/watch?v=3bE4bHBVB6k
2. SC-related positions, jobs, roles etc.:
    - https://www.youtube.com/watch?v=Mh8KCRcQtRM
    - https://www.youtube.com/watch?v=HN5dDOGgKVA
    - https://www.youtube.com/watch?v=7qGAIaKqAuE
    - https://www.youtube.com/watch?v=bQKE5Uu5TNo
    - https://www.youtube.com/watch?v=O6ry5U9pHqE
    - https://www.youtube.com/watch?v=kkbc2PUxpY0

Some meaningful examples:

- Amazon (old) SC: https://www.youtube.com/watch?v=Y-lBvI6u_hw
- IKEA (unique) Supply Chain: https://www.youtube.com/watch?v=DBrl356VhqQ
- Walmart SC: https://www.youtube.com/watch?v=yZC4neLax5o
- Relevant journals for further readings (in alphabetical order)
- IJLDM: https://www.emerald.com/insight/publication/issn/0960-0035
- IJOPM: https://www.emeraldgrouppublishing.com/journal/ijopm
- IJPE: https://www.journals.elsevier.com/international-journal-of-production-economics
- IJPR: https://www.tandfonline.com/toc/tprs20/current
- JOM: https://onlinelibrary.wiley.com/journal/18731317

- JPSM: https://www.journals.elsevier.com/journal-of-purchasing-and-supply-management
- JSCM: https://onlinelibrary.wiley.com/journal/1745493x
- PP&C: https://www.tandfonline.com/loi/tppc20
- SCM: https://www.emerald.com/insight/publication/issn/1359-8546

Related Institutions other than Universities

- APICS: http://www.apics.org/
- CIPS: https://www.cips.org/

057013 Green Logistics

(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

The course assumes that students have a basic knowledge of logistics management. Students that do not have such basic knowledge will be provided with references and material to fill the gap.

Learning Objectives

With increasing quantities of goods moving across the globe, growing environmental regulatory pressures and increasing customers' expectations, sustainable logistics has now become one of the key business areas for companies to compete, be successful and thrive in nowadays business environment. The course aims to provide students with the capabilities to master advanced managerial issues related to Sustainable Logistics operations. Understanding the environmental impact of complex logistics systems, identifying the practices and actions that can be undertaken by managers to embrace more sustainable logistics strategies and design greener logistics networks, becoming aware of the tools and methods for sustainability quantification, analysing the company's green logistics performance over a set of relevant KPIs will be among the key topics.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modelling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

1. Understand and describe:
    - The main green logistics strategies and their consistency with the general company strategy
    - The main practices and actions that can be undertaken in the arena of green logistics, with reference to key aspects such as network design, transport, warehousing, and logistics innovation
    - The main methodologies for sustainability quantification and company's green logistics performance analysis
2. Apply the theories, models, principles and criteria to understand and address real-world problems related to green logistics

3. Design and illustrate innovative logistics solutions in new fields (e.g. sustainable B2c eCommerce and last mile delivery)

Topics Covered

- **Sustainability in Logistics as a strategic priority for companies.** Definition of Green Logistics. Evolution of the concept over time. Triple Bottom Line (TBL) and SDG frameworks. Types of environmental impact. Green logistics and corporate strategy.
- **Assessing Green Logistics: frameworks and quantification methods.** Guidelines, metrics and measures. GHG Protocol, ISO standards, GLEC framework. The carbon footprint of logistics activities.
- **Sustainable logistics network and green transport.** Design and management of green logistics networks. The role of transport in greening logistics networks and types of sustainable transport solutions. Cost, service and sustainability performance. Sustainability performance quantification.
- **Green warehousing.** Energy-efficient solutions for warehousing. Best practices and impacts on corporate performance. Assessment of the environmental impact of logistics sites. Systems for monitoring green performances (e.g. 'Green IT').
- **Sustainability strategies for city logistics and last mile deliveries.** Innovative last mile delivery solutions. Impacts on efficiency, effectiveness and environmental sustainability. City logistics networks. Crowdsourcing logistics in urban environment. Relationship between service level and sustainability.
- **New models of collaboration towards sustainability.** Collaborative practices. The role of logistics service providers (LSPs) in improving sustainability.
- **The impact of logistics on social sustainability.** Logistics solutions for reducing food waste.
- **Innovation in logistics and sustainability implications.** B2c eCommerce. Sustainable packaging. Reverse Logistics. Logistics 4.0 and sustainability.

Bibliography

Recommended materials

A. McKinnon, M. Browne, M. Piecyk, A. Whiteing, Green logistics: improving the environmental sustainability of logistics, Editore: Kogan Page, Anno edition: 2015, ISBN: 978-0749471859

D.B. Grant, A. Trautrims, C.Y. Wong, Sustainable logistics and supply chain management: principles and practices for sustainable operations and management, Editore: Kogan Page, Anno edition: 2017, ISBN: 978-0749468668

056512 High-End and Luxury Industries Management
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No significant preliminary competences and knowledge are required. Some of the case studies will be taught with a "flipped classroom" approach. It means that students will have to study the relevant materials **before** the class, and to attend the class well prepared for maximum training effectiveness.

Learning Objectives

The present course is designed in collaboration with Altagamma[5] to illustrate the fundamental of the sector and create a link between theory and practice in the key processes along the value chain of high-end and luxury goods companies. Several case studies will be discussed, with particular emphasis on Italian leading companies, to understand the most relevant perspectives. The course approach will be Hands-On and based on real cases discussion, to allow participants to see the key principles of High-End and Luxury Management applied in practice.

Expected Learning Outcomes

Specifically, by the end of the course, participants are expected to have reached the following Learning Objectives:

- To know the fundamentals of premium and luxury market today and luxury Critical Success Factors and to be familiar with recent market trends in high-end and luxury consumption;
- To understand the key theoretical principles behind sound luxury strategy and execution and to see how these principles work in real cases;
- To evaluate the strategy of a brand, identifying strengths and weaknesses, and be able of clearly communicate to different audiences the points of parity and points of difference of a specific brand in a given market;
- To acquire basic definitions (e.g. Manufacturing, Production Process, Supply Chain) as well as an overview of the paramount actors and processes along SCM for Luxury firms;
- To understand the link between (product-related) Luxury Critical Success Factors and the way customer requests are handled and to be able to design a customer-oriented strategy in a luxury company;
- To be able to apply the contents of the course to a real problem and deliver an effective presentation to company representatives.

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[5]Since 1992, Altagamma Foundation gathers High-End Italian Cultural and Creative Companies, recognized globally as authentic ambassadors of Italian style. The mission of the Foundation is to increase the competitiveness of the High-End industry, contributing to Italy's economic growth. Altagamma members operate in multiple sectors among which fashion, design, jewelry, food, hospitality, automotive, yachts and wellness. Find out more on www.altagamma.it

Topics Covered

The luxury sector fundamentals:

- The origins of the concept of luxury
- Facts & Figures: 20 years of Altagamma Monitor
- Academic definitions and national approaches (Altagamma, Comité Colbert, Meisterkreis, the Walpole Society)
- Where and how is "value" created? Critical Success Factors of a luxury brand; symbolic vs technical brands; from the Veblen effect (never scientifically demonstrated) to Bandwagon and Snob effect; different customer profiles for luxury and high-end products and services.

Anatomy of the luxury value chain:

New Product Development:

- Focus on Personal Luxury Goods – Apparel/Footwear/Accessories: New Collection Development; timing and critical aspects
- Focus on complex products (cars, yacths, design/furniture): co-design and other collaborations with supplier

Supply Chain Management (SCM):

- Luxury SCM: do consolidated SCM models and theories apply?
- Make or Buy; sourcing strategies; manufacturing: craftsmanship at the origin of true luxury.
- Luxury and Sustainable Supply Chain Management

Distribution:

- Distribution channels and retail formats; distribution agreements; selecting the most appropriate format.

Retail:

- Managing Directly Operated Stores (DOS); managing the eCommerce channel and developing an omnichannel strategy.

Production and Distribution Planning:

- Choice of number of echelons and Order Penetration Point positioning; optimal management of trade-off between stock-out and over-stock (application of Newsvendor model to the case of Personal Luxury Goods distribution).

Innovation and digital solutions

- Digital solutions for the luxury supply chain: case histories and Software Demonstrations:
- Design / New Product Development: CAD/CAM and Product Lifecycle Management (PLM);
- Production Planning: Stealth;
- Digital solutions to support the analysis of environmental impact along the product lifespan – Product Lifecycle Assessment (LCA).
- Case 1: digital technologies to support optimal customer experience in retail – from the fist failures to a necessity in the post-Covid new scenario;
- Case 2: traceability and transparency, efficiency and effectiveness along the supply chain –RFID solutions and blockchain projects;
- Case 3: prototyping virtualization, online fashion shows and virtual showrooms – less costs, less travels, shorter time-to-market, without impacting on quality.

Bibliography

Main textbooks

Brun Alessandro and Cecilia Castelli, Supply chain strategy in the fashion industry: Developing a portfolio model depending on product, retail channel and brand." International Journal of Production Economics, Anno edition: 2013

Brun Alessandro and Antonella Moretto, "Contract design and supply chain management in the luxury jewellery industry." International Journal of Retail & Distribution Management, Anno edition: 2012

Brun Alessandro and Moretto Antonella, Organisation and supply chain for quality control in luxury companies. Journal of Fashion Marketing and Management., Anno edition: 2014

Recommended materials

Love Ranga, The Ghost of Luxury

Kapferer, Bastien, The Luxury Strategy: break the rules of marketing to build luxury brands

Chevalier, Gutsatz, Luxury Retail Management: how the world's top brands provide quality product & service support

Rigaud, Pini, New Luxury Management: Creating and managing sustainable value across the organization

059149 Human-System Interaction in Operations

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No specific pre-requisites.

Learning Objectives

This course aims at outlining relevant developments in manufacturing and service industries with regard to automation and digitalization developments. This is especially tailored towards the new Industry 5.0 (I50) concept of human-centered operations systems. Therefore, the course wants to address the challenge of Human-System Interaction (HSI) and the design of successful human-centered systems. HSI is critical in modern operations and supply chain management due to the increasing use of automated and digital systems. Counter-intuitively during automation and Artificial Intelligence (AI) applications, the human factor is increasing in importance in terms of operational performance and business success. In most empirical evidence studies within operations management we find that hybrid systems are performing best, combining the strengths of automated and computer systems with human workers.

Expected Learning Outcomes

This course aims to provide the main methodologies and criteria for analysing, designing and managing hybrid, i.e. human-digital work systems in logistics, manufacturing and supply chain systems. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities for the participants:

• Understand context, functions, processes in a hybrid (human-technology interaction) operations system and their impact

• Identify trends, technologies and key methodologies in a specific application domain

• Design solutions applying a scientific approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a

solid and rigorous multidisciplinary background) to face challenges and opportunities in practical environments with HSI

• Understand and describe the main challenges in hybrid systems for digital operations systems and their interaction with

the general company strategy [Understand]

• Define an evolving HSI operations strategy of a company, based on both its operations processes and the its general

digitalization and business strategy [Understand and Identify]

• Understand and describe: the main HIS stages of Safety, Efficiency and Trust (SET) the following exemplary fields:

manufacturing, transport, inhouse logistics (storage and picking), and service processes like for example healthcare

[Understand and Identify]

• Identify and present innovative HSI solutions in new fields (e.g. service processes, maintenance) [Identify and Design]

• Apply criteria, methodologies and models to hybrid operations / HSI challenges in order to: design and manage digital

operations systems with AI / ML / Robotics applications in a service and industry contexts [Design].

Topics Covered

Industry applications of Industry 5.0 for example in the following sectors:

- Manufacturing
- Logistics
- Retail
- Health Care

Sustainable Development Goals (SDGs)

This course contributes to achieve the following Sustainable Development Goals:

- **SDG8 - DECENT WORK AND ECONOMIC GROWTH** (4 h)
- **SDG9 - INDUSTRY, INNOVATION AND INFRASTRUCTURE** (6 h)
- **SDG12 - RESPONSIBLE CONSUMPTION AND PRODUCTION** (2 h)

Bibliography

No texts suggested.

058370 Improvement and Innovation Toolbox
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

- Competences in Operations management and logistics are extremely useful
- Additional competences in Industrial Technologies are also appreciated
- Basic knowledge of accounting
- Good knowledge of basic mathematics and statistics

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

The student successfully taking this course is expected to:

- Understand the context, and the problem to solve/opportunity to improve
- Apply scientific methods and tools to collect data, analyse them in a structured way so to find the root causes of the problem, design countermeasures, implement them, check the results and take consequent actions
- Interact with other members of the team that is working on the problem, and with the other people involved, in a constructive way.

Topics Covered

TOOLBOX

To provide analytical and problem-solving tools:

- A framework for problem setting and problem-solving: the famous A3 of Toyota Business Practice.
- Measurement System Analysis
- Analysis and graphical representation of a data set
- Design of Experiment
- Simulation
- Clustering
- Anova

- Multicriteria decision making

Bibliography

No texts suggested.

055016 Industrial Asset Management

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Students are recommended skills and competences in design and management of production systems.

Learning Objectives

The goal of the IAM course (second half of the semester) is to introduce the student to Industrial Asset Management, intended as an integrated methodology to optimize the management of the physical assets along the lifecycle. Currently defined as "the coordinated activities of an organization to realize value from assets" (ISO 55000), Asset Management provides a major focus on the long-term strategic perspective, orchestrating decisions and activities in various asset lifecycle stages (including design, commissioning, maintenance, operation, decommissioning). This is becoming popular in the industrial world, where attention is given to physical assets, equivalently industrial assets. The course will then address the evolution of the discipline in the management across different sectors, including manufacturing plants, fleets of assets, infrastructures as exemplary cases of application.

The IAM course fits into the overall program curriculum, pursuing some of the defined general learning goals and, in particular, contributing to the development of the following capabilities:

- **Understand** context, functions, processes, resources and decisions of Industrial Asset Management, and their impacts in terms of asset-related performances, costs and risks;
- **Identify** trends, technologies and methodologies to support decision-making to manage the lifecycle of industrial assets, in light of the stakeholders' requirements and the objective to balance performances, costs and risks;
- **Design** solutions for Industrial Asset Management, to orient towards realizing a sustainable value from assets based on smart approaches to balance performances, costs and risks in a business and industrial environment.

Expected Learning Outcomes

The expected learning outcomes of the IAM course, achievable through lectures and exercise/case study sessions, consist of knowledge and understanding of the criteria and methods to support decisions for Industrial Asset Management, and of the practical abilities to analyse performances, costs and risks to support a smart decision-making in the asset lifecycle. In particular, the course will allow students to achieve knowledge and understanding in order to:

- Name and define, with precise terminology, context, functions, processes, resources and decisions within the scope of Industrial Asset Management;
- Recognize and discuss the role of Industrial Asset Management for what concern its impacts in terms of reliability, availability, quality, safety, throughput and costs;
- Describe and explain the main performances, costs and risks impacted by a smart approach to manage the asset lifecycle;

- Describe and explain the main criteria, modeling techniques / methods, and methodologies to support a smart approach to manage the asset lifecycle;
- Identify**,** describe and analyse the use of key enabling technologies for a smart decision-making support based on data analytics and simulation techniques, including novel perspectives taken from virtualization of industrial assets (also known as Digital Twins).

The course will also allow students to be able to practically apply the acquired knowledge and understanding in specific problem settings, proposed in the exercise/case study sessions and requiring abilities of analysis and synthesis, leading to:

- Distinguish different contexts and requirements identified in specific problem settings, eventually being able to understand problems and opportunities in a given business and industrial environment and to formulate the goals in terms of performances, costs and risks addressed by the physical assets;
- Analyse the data sets provided within specific problem settings, to assess and/or to predict the related performances, costs as well as the risks due to uncertainties in attainment of the goals;
- Design solutions for a smart approach to manage the lifecycle of industrial assets, considering contexts and requirements due to specific problem settings, targeted performances and costs, and the requirements for risk mitigation.

Hence, through exercise/case study sessions, students will acquire the skills to formulate a judgment, meaning to distinguish specific problem settings, analyse the data sets provided with these settings, and design solutions for cost-effective decisions asset lifecycle management.

Topics Covered

The goal of the course is to introduce the student to the evolution of Asset Management in industry, looking at the capabilities an industrial organization should be able to build. These capabilities serve to achieve a systematic and coordinated practice in order to sustainably manage the organization's physical assets and their associated performances, risks and expenditures over the lifecycles, with the purpose of contributing to the achievement of the organizational strategic plan. This is achievable thanks to the co-evolution of the business needs and requirements, novel practices in the operations, and use of the key enabling technologies especially due to the digitalization. Considering all developments and expected trends, the following topics are presented during the lectures and practically tested by means of exercise/case study sessions, including also invited speakers bringing their experience from different industrial settings:

- Role of Asset Lifecycle Management in industrial organizations in different sectors, dealing with factories, fleets and infrastructures
- Asset Management system and its integration in the industrial organization through key dimensions (built as a hierarchy of asset control activities and stages along the asset life cycle) and principles (including lifecycle, system, risk, value, and asset-centric orientation)
- Value based Asset Management to support coordinated activities of an industrial organization to realize value from their physical assets
- Methodologies, methods, techniques for asset performance management along the lifecycle, focused on system-level performance evaluation in uncertain scenarios, and considering system-level requirements of reliability, availability, quality, safety, and throughput
- Metrics for asset performance management: from Overall Equipment Effectiveness to Overall Line and Factory Effectiveness

- Strategic risk and cost analysis of industrial assets, including asset criticality assessment and total cost of ownership evaluation
- Management of the resources required for logistic support of industrial assets: spare parts management and maintenance services
- End of life management of industrial assets, looking at the adoption of asset integrity management and asset life extension practices
- Information management along the asset life cycle, including key enabling technologies as Computerized Maintenance Management System, Smart maintenance systems, and Asset Performance Management software tools.

Bibliography

Main textbooks

Lecture slides and tutorials https://beep.metid.polimi.it

Recommended materials

A. Crespo Marquez, The Maintenance Management Framework. Models and Methods for Complex Systems Maintenance, Editore: Springer, Anno edition: 2007

Andrew K.S. Jardine, Albert H.C. Tsang, Maintenance, Replacement, and Reliability. Theory and Applications, Editore: CRC Press, Anno edition: 2013

J. Lee, Industrial AI. Applications with Sustainable Performance. Editore: Springer, Anno edition: 2020

L. Furlanetto, M. Garetti, M. Macchi, Principi Generali di Gestione della Manutenzione, Editore: FrancoAngeli, Milano, Anno edition: 2006

L. Furlanetto, M. Garetti, M. Macchi, Ingegneria della manutenzione, Editore: FrancoAngeli, Milano, Anno edition: 2007

L. Furlanetto, M. Garetti, M. Macchi, Pianificazione, organizzazione e gestione tecnico-economica della manutenzione, Editore: FrancoAngeli, Milano, Anno edition: 2011

A. Crespo Márquez, M. Macchi, A. K. Parlikad, Value Based and Intelligent Asset Management: Mastering the Asset Management Transformation in Industrial Plants and Infrastructures, Editore: Springer, Anno edition: 2019

J. E. Amadi-Echendu, K. Brown, R. Willett, and J. Mathew, eds., Definitions, concepts and scope of engineering asset management, Editore: Springer, Anno edition: 2010

J.D. Campbell, A.K.S. Jardine, J. McGlynn, Asset management excellence: optimizing equipment life-cycle decisions, Editore: CRC Press, Anno edition: 2016

N.A.J. Hastings, Physical Asset Management, Editore: Springer, Anno edition: 2010

056950 Industrial Automation and Robotics

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

There are no specific prerequisites to attend this course, apart from knowledge of basic concepts in calculus and linear algebra.

Learning Objectives

The goal of this course is to provide the students with a general view of the current methods and tools offered by automation technologies for the smart factory, including industrial and collaborative robotics. The course will also discuss technological aspects for the implementation of the automation systems, with specific reference to digital control, programming of logic controllers, communication protocols, and programming industrial robots.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

At the end of the course, the student is expected to:

- Understand the role of automation systems for the smart factory;
- Manage the design of simple automation systems in terms of both discrete and continuous control;
- Understand the communication technologies for industrial IoT systems;
- Identify the role of industrial robots in the factory, why and where they should be used in the production systems;
- Understand and master the new trends in industrial robotics, like collaborative robotics;
- Use software programs to simulate and to offline program the robots.

Topics Covered

Introduction

Automation: current and future scenarios. The industry 4.0 paradigm. Human-centric automation.

Process automation
The control problem. The role of the dynamics in control systems. State models and transfer functions. Closed-loop control: the role of feedback. Industrial controllers. Digital control technology. Application: motion control.
Discrete automation
Action sequencing and logic control. Task scheduling in an automation plant. The Programmable Logic Controller. Programming languages: Ladder Diagrams and Sequential Function Charts (SFC). Real-time systems.
Communication technologies and protocols
Technologies and protocols for interconnecting industrial devices and processes: industrial ethernet and fieldbus. Protocols to provide services in industrial environments.
Industrial and collaborative robotics
Industrial robots. Selection of a robot based on the application. Robot kinematics, motion planning and control. Tools for robot motion programming. Collaborative robotics: advantages in human-robot collaboration. Safety standards. Examples and applications.
AI-driven production control
Methods and tools for production control in mixed human-robot lines, based on digital twins of the plant and closed-loop scheduling/dispatching rules.

Bibliography

Recommended materials

Karl Johan Astrom and Richard M. Murray, Feedback systems - An Introduction for Scientists and Engineers https://www.cds.caltech.edu/~murray/books/AM05/pdf/am08-complete_22Feb09.pdf

Norman S. Nise, Control Systems Engineering, Editore: John Wiley and Sons, Inc., ISBN: 978-0470917695

B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo, Robotics: Modelling, Planning and Control, 3rd Ed., Editore: Springer, Anno edition: 2009, ISBN: 9781846286414
http://www.springer.com/engineering/robotics/book/978-1-84628-641-4

058369 Industrial Management Lab and Toolbox

(15 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

- Competences in Operations management and logistics are extremely useful
- Additional competences in Industrial Technologies are also appreciated
- Basic knowledge of accounting
- Good knowledge of basic mathematics and statistics

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

The student successfully taking this course is expected to:

- Understand the context, and the problem to solve/opportunity to improve
- Apply scientific methods and tools to collect data, analyse them in a structured way so to find the root causes of the problem, design countermeasures, implement them, check the results and take consequent actions
- Interact with other members of the team that is working on the problem, and with the other people involved, in a constructive way.

Topics Covered

The course has three parts that run in parallel:

TOOLBOX

To provide analytical and problem-solving tools:

1. A framework for problem setting and problem solving: the famous A3 of Toyota Business Practice.
2. Measurement System Analysis
3. Analysis and graphical representation of a data set
4. Design of Experiment
5. Simulation

6. Clustering
7. Anova
8. Multicriteria decision making

SOFT SKILL

Seminars to:

- Better understand and manage relationships and time
- Develop effective presentations

LAB IMPROVEMENT PROJECT

Students work in groups, and each group will be assigned a Company project, a Company tutor and an Academic tutor. The content of the project will be to solve a problem/make improvement in the area of Industrial Management of manufacturing, service, or consultancy companies. Each group is responsible to set the targets, together with the company, and to carry out the project at the best of its capabilities, following the A3 methodology.
The overall effort required is about 250 hours per person.

Bibliography

No texts suggested.

096090 Industrial Technologies

(10 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec) & Spring Semester (Feb – May)

Prerequisites

For students coming from other universities or other Bacs than Management Engineering, it is suggested to have a background in production and operations management. Such a background can be retrieved also accessing the Operations Management MOOC provided by Politecnico di Milano in the Polimi Open Knowledge (POK) platform.

Learning Objectives

The goal of the course is to enable students to master the configuration and the design of production systems according to the required performance targets (flexibility, productivity, responsiveness). The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes, and impacts on operational and business performances resulting from factors decided when defining the configuration and the design of production systems;
- Identify and analyse some industrial technologies and the related managerial and organizational issues;
- Design solutions within different configurations of production systems based on the application of a scientific and engineering approach to face problems and opportunities in a business and industrial environment.

Expected Learning Outcomes

The main expected learning outcomes of the course, achievable through lectures and exercise sessions, consist of knowledge and comprehension of the main criteria and methods for the design of production systems, as well as of the practical abilities to analyse the features of different configurations and industrial technologies and to, correspondingly, synthesize design solutions.

In particular, the course will allow students to achieve knowledge and comprehension in order to:

- Name, with precise terminology, context, functions and processes implied within different configurations and design of production systems;
- Describe and explain the general features, strengths and weaknesses pertaining to different configurations of production systems, while relating, in each configuration, to different functions, processes and impacts on operational and business performances;
- Describe and explain the main criteria, approaches, methods and mathematical formulations to provide rough design solutions for different configurations of production systems;
- Describe and explain the modelling criteria and methods to provide detailed design solutions after performance assessment and verification in view of the stochastic nature of activities in production systems;

- Identify, describe and analyse the main features of some industrial technologies and their implications in terms of managerial and organizational issues.

The course will also allow students to be able to practically apply the acquired knowledge and comprehension in specific problem settings, proposed during the exercise sessions and requiring abilities of analysis and synthesis, leading to:

- Distinguish different contexts and requirements identified in specific problem settings, eventually being able to understand problems and opportunities in a given business and industrial environment and to formulate the goals in terms of performance targets and main design variables;
- Analyse the data sets provided within specific problem settings, to estimate the achievable performances and costs;
- Design solutions within different configurations of production systems, considering the contexts and the requirements due to specific problem settings, the achievable performances and costs.

Topics Covered

The following topics are presented during the course:

1. Analysis of the characteristics, scope, design, management and organizational issues of the different configurations of production systems;
2. Criteria, approaches and methods for the design of manufacturing systems (job shop, manufacturing cells, transfer lines);
3. Criteria, approaches and methods for the design of manual assembly systems (fixed position assembly, paced and un-paced lines, continuous flow lines, multi-model and mixed-model lines, assembly shop, assembly cells);
4. Criteria, approaches and methods for the design of automated assembly systems (lines, flexible assembly systems);
5. Criteria, approaches and methods for the design of process plants;
6. Analysis of some industrial technologies (e.g.: food, paper, cement, ceramics, glass, semiconductors) and related management and organizational issues;
7. Criteria and methods for performance assessment and verification of design solutions in view of the stochastic nature of activities in production systems (factory physics principles and laws, Monte Carlo and Discrete Event simulation applied to manufacturing processes and systems).

Bibliography

A. Portioli Staudacher, A. Pozzetti, Progettazione dei sistemi produttivi, Editore: Hoepli, Anno edition: 2003, ISBN: 8820331985

Hopp, Wallace J., and Mark L. Spearman, Factory Physics. 3rd ed., Editore: Illinois: Waveland Press, Anno edition: 2011

052711 Infrastructure Investment and Project Finance

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

The course aims to provide students with theoretical frameworks and tools to structuring, valuing, financing, and managing large, complex, infrastructure investments with particular reference to the Transport sector (roads, highways, bridges, tunnels, rail, metro, mass transit, trams, airports, ports). The course will provide the students the necessary knowledge in the fields of infrastructure investment and funding sources. The course will consist also of lectures and talks by guest speakers from NPBs, investment funds, and experts from National/Regional authorities.

Expected Learning Outcomes

In terms of acquired knowledge and understanding, students will be able to: 1) Identify how public sources, debt, equity, and hybrid instruments can be combined to sustain infrastructure projects; 2) Describe the relationships between sound theoretical references in corporate and project finance and the concrete funding of infrastructure projects; 3) Examine different types/sources of risks at different stages of project development and the corresponding expected rewards; 4) Define the main contractual arrangements in infrastructure development projects: infrastructure financing as a network of contracts; 5) Show references to, and analysis of, several concrete case studies in the financing of infrastructures; 6) Understand the main concepts of Project Management (Scope, Time and Cost Management).

Concerning the ability to apply the acquired knowledge and understanding, students will be able to: 1) Apply the theoretical knowledge for the practical analysis of real infrastructure projects; 2) Calculate economic and financial indicators to evaluate infrastructure projects performances; 3) Compare alternative financial structures for infrastructure projects based on the usage of different financial instruments; 4) Illustrate the allocation of risks in infrastructures projects comparing advantages and disadvantages of alternative contractual arrangements in infrastructure development projects; 5) Examine project performances in terms of Scope, Time and Cost management; 6) Apply a real Economic Financial Plan Model.

Finally, students will improve their communication skills, being able to prepare financial analysis of real infrastructure projects, summarizing the main outcomes of their analysis through a set of synthetic indicators.

Topics Covered

The course contents are delivered through lectures and exercises sessions. The course covers the following topics divided in modules as per the description below:

- Project Management

Project Management Environment and Lifecycle;

Project Scope Management;

Project Time Management;

Budget Definition and Project Monitoring and Control.

- Project Finance

Basic Corporate Finance Concepts;

Project Finance vs Corporate Finance;

The Architecture of Concession Contracts;

Financial Modelling for Infrastructure Projects;

Financial Risk Assessment;

Bibliography

Main textbooks

Delmon, Jeffrey, Private sector investment in infrastructure: Project finance, PPP projects and risks, Editore: Kluwer Law International, Anno edizione: 2009

Project management body of knowledge (pmbok guide), Editore: Project Management Institute

057071 Innovation in Action Lab

(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

The course of Economics of Innovation and New Technology (first term) is mandatory for the Major in Innovation Management. Depending on the company project assigned, the students may be advised to take one or more specific courses among those offered during the second term. This choice is going to be made at the beginning of Term 2, when the students can still edit their curriculum.

Learning Objectives

The lab challenges the students to move from learning to action and accomplish a real-life company project. At the beginning of the spring term, the students organize in teams of 2-3 members. Each team is assigned to a partner company and to a competent academic tutor. The company explains the challenge and outlines a set of clear and measurable goals that the students should accomplish. The students are expected to work at the company's premises approximately once/twice a week for 15 weeks approximately from March to June or September. The students work towards meeting the goals outlined at the beginning of the project in a clear and measurable way.

The outcome is a concluding presentation in front of the partner company. The assessment is based on reaching the goals assigned jointly by the company and the academic tutor.

Project's targets are defined directly by the company at the beginning of the project, in terms of clear and measurable outcomes. Teams are expected to work at the company's premises and report on a weekly-basis to the company associate tutor and the academic tutor about their progress towards the goal

Expected Learning Outcomes

Participants will learn to:

- Analyse a real-life problem with the most appropriate concepts, practices and tools among those learned in the mandatory modules.
- Apply analytical skills and creative thinking to identify and apprise the spectrum and pros/ cons of alternative solutions.
- Generate new practical, innovative and reliable solutions for company business issue
- Negotiate a line of intervention, which leads to success, while fitting to the company strategy and timeline.
- Act as a professional intrapreneur or innovation consultant by practicing self-disciplined creativity, analytical thought, leadership and group-work.

Topics Covered

Each challenge (company project) is unique and assigned directly by the company.
This ensures that the topic is always up-to-date with the latest market and industry trends.
The professor and tutor assign the projects considering the teams' preferences.

Examples of challenges include:
- Outline the patent and IP strategy of a new product,
- Outline the strategy and implementation plan for a new digital service,
- Scout new technology introduction for the delivery/production process of the company,
- Support R&D function in design new product and its launch into the market,
- Set call for ideas/challenges for innovation.

The students will be further supported by a cycle of seminars of professional development aimed at strengthening the soft skills of participants.

Bibliography

No texts suggested.

057036 Innovation in Health and Social Care

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

This course is open to all students, without specific requirements. Students will gain familiarity with health and social care in the first lectures.

Learning Objectives

This course teaches the fundamental concepts, theoretical frameworks, and exemplary cases to understand innovation and innovation management in health and social care. Students will get familiar with the peculiar challenges of (i) generating new products and services, (ii) collecting evidence through different clinical studies to validate them, and (iii) commercializing these innovations through original business models. Students will develop an in-depth understanding of the key challenges faced by the most relevant stakeholders in the health and social ecosystem (e.g., MedTech and pharmaceutical companies, healthcare professionals, hospital managers, regulatory agencies, etc.) that are involved in the different phases of the innovation process.

The theory will be always matched with practice, and, in this view, senior managers and professionals, international experts will join lectures to share their experience and thoughts about the next-generation health and social care. After introducing Students to a preliminary understanding of the health and social care ecosystem, lectures will cover three main topics: (i) challenges of innovation and innovation management in health and social care; (ii) assessment of health and social care innovation from a multi-perspective approach; and (iii) go-to-market strategies for health and social care innovation with a focus on institutional, out-of-pocket, and data-based (platforms) business models. The competencies developed in this course will be valuable for all Students, who are interested to practicing innovation in professional, knowledge-intensive and regulated contexts.

Expected Learning Outcomes

- Understand challenges, functions, processes in the health and social care ecosystem, and their mutual effects on business, economy, environment, and society
- Identify trends, technologies, key methodologies, and stakeholders' needs in the health and social care ecosystem
- Develop new ideas and transformative solutions to deliver positive impact on business, industrial and social scenarios evolving over time (through the project work)

Topics Covered

Topic 1: Specificities and challenges of innovation management in health and social care

- Value-based Health Care (VBHC)
- Technology lifecycle in health and social care
- Focus on medical devices and digital therapeutics: challenges and peculiarities
- Theories of diffusion and acceptance/adoption in health and social care

- Evidence-Based Management (EBMgmt) in Healthcare and performance improvement

Topic 2: Assessment of health and social care innovation

- Health Technology Assessment (HTA) and Cost-Utility Analysis (CUA)
- Investment vs. Disinvestment in health and social care
- Hospital strategies about innovation and new technologies
- Technology Assessment in Hospitals (HBHTA): goals, organizational configurations, methods, performance

Topic 3: Go-to-market strategies for health and social care innovation

- Market Access and regulatory challenges
- Real-World Evidence (RWE)
- Business models in health and social care: institutional, out-of-pocket, and freemium (platforms)

Bibliography

No texts suggested.

057878 Integrated Manufacturing Systems B

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Students are required to know the principles and methods of basic inferential statistics. The topics that must be known are:

- Statistical distributions: exponential, uniform, triangular, normal, beta, t-student, chi-square, Fisher, Bernoulli, Poisson.
- Confidence Interval and Tests: general framework of confidence intervals, general framework of standard tests with two hypotheses (H0 and H1), p-value concept, test about one or two means, tests about one or two variances.
- Test to assess normality.
- Correlation and autocorrelation measures.

Basic knowledge of Microsoft Excel and MATLAB will be requested for data analysis.

Learning Objectives

The course will allow students to analyse the performance of complex manufacturing systems using simulation models.

Expected Learning Outcomes

By the end of the course, students will learn contents and practices according to what defined in the leaning objectives.

In terms of acquired knowledge and understanding, through lecture sessions students will be able to:

- Identify the main elements of integrated manufacturing systems and their relationships
- Describe the basic principles of discrete event simulation
- Discuss the basic analysis methodologies in the context of simulation.

Concerning the ability to apply the acquired knowledge and understanding, through classwork students will be able to:

- Model several integrated manufacturing systems using discrete event simulation software: manufacturing lines, assembly lines, flexible manufacturing systems
- Set up simulation models with data input analysis techniques
- Understand system behaviour with data output analysis techniques
- Rank and compare alternative manufacturing systems using simulation outputs.

Through Group Project Work activities, students will develop the ability to handle the complexity of manufacturing systems, to integrate knowledge acquired in other courses on productions systems and industrial plants, to formulate judgments with incomplete and uncertain data, to study in a manner that may be largely self-directed and/or autonomous. In particular, Project Work activities will allow students to:

- Autonomously analyse and design an integrated manufacturing system in a context of partial information
- Obtain data and acquiring knowledge from experiments in a physical laboratory

- Choose the modeling detail level from the physical system to the conceptual model
- Choose computer coding strategies for building simulation models in a software platform
- Support their choices and conclusions.

Finally, students will improve their communication skills, being able to summarize and present the results with technical documents and oral presentations to specialist audiences.

Topics Covered

The course consists of lectures and classwork modules on presence. A classwork module will be delivered in Computer Lab to allow students to use state-of-the-art software for simulation of manufacturing systems. In Physical Lab students will be required to make experiments oriented to accomplish problem-solving activities in the Group Project Work. The course covers the following topics divided into modules as per the description below:

Module 1 Base elements of integrated manufacturing systems

Students will learn the base elements of integrated manufacturing systems as well as their performance measures, abstraction levels, and design criteria.
List of contents - Introduction to integrated manufacturing systems. Main elements: stations, buffers, transporters, tools, fixtures, and pallets. Flexible Manufacturing Systems. Machining lines. Assembly lines. Job shops. Performance indicators. Relevant design variables.

Module 2 Simulation for integrated manufacturing systems.

Students will learn simulation techniques for estimating the performance indicators that are critical in the design and management of integrated manufacturing systems.
List of contents - Types of simulation: discrete event simulation, continuous simulation, agent-based simulation. Formal modeling languages. Random number generation. Random variate generation. Input modeling. Output analysis. Verification and validation. Selection of alternatives. Variance reduction using common random numbers. Management of simulation projects.

Module 3 Laboratories

<u>Computer Lab</u>.
Students will receive the essential theoretical and practical elements for creating and executing, in a dedicated software environment, valid simulation models representing integrated manufacturing systems. Students will also be supported by tutorial videos developed ad hoc for this course.
List of contents – Arena software environment. Process-oriented modeling concepts. Controlling pseudo-random numbers in simulation experiments. Collecting simulation statistics. Reading/writing from external sources. Implementing Common Random Numbers technique. Comparison of alternatives.
<u>Group Project Lab</u>
The objective of group projects is to help students in applying the approaches and principles we teach in class. The project will be assigned throughout the semester. Project results are expected to be released within the first exam session, the specific deadline will be defined by the time the project will be assigned. The evaluation of the project will be based on the produced Project Report and on a presentation. The project laboratory will require Experimental Lab sessions.
<u>Experimental Lab</u>

Students will be required to study and improve a given manufacturing system. List of contents – Data collection, conceptual modeling, model validation.

Bibliography

Recommended materials

Averill M. Law, Simulation Modeling and Analysis, Editore: Mc Graw Hill, Anno edition: 2013, ISBN: 978-0-07-340132-4

Barry L. Nelson, Foundations and Methods of Stochastic Simulation. A First Course, Editore: Springer, Anno edition: 2013, ISBN: 978-1-4614-6159-3

Stewart Robinson, Simulation. The Practice of Model Development and Use, Editore: Palgrave MacMillan, Anno edition: 2014, ISBN: 978-1-137-32802-1

097316 International Distribution
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

The International Distribution Course assumes that students have a basic knowledge of Logistics Planning Models (e.g. Inventory Management). Students that do not have this basic knowledge will be provided with references and material (e.g. slides, MOOCS) to fill the gap.

Learning Objectives

In recent years the international trade has grown significantly. Assuming a company perspective, the course aims at examining International Distribution in terms of logistics channel and trade channel design. The main international logistics variables underpinning the international distribution are deepened. Special attention is given to emerging markets and company size (medium company vs. multinational company).

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

1. Understand and describe the main strategies for setting a global logistics network and their consistency with the general company strategy
2. Understand and describe the main solutions/alternatives in the following fields: transport modes, customs, outsourcing in a global context, trade channel, planning of logistics flows, management of financial flows and incoterms
3. Apply criteria, methodologies and models to distribution problems in order to: design and manage global distribution networks
4. Identify innovative solutions in managing global networks (e.g. entering new markets)

Topics Covered

1. International transportation. Features of the main transportation modes (ocean shipping, air shipping); types of services (e.g. FCL, LCL, groupage airfreight, charter airfreight); transportation networks (e.g. hub and spoke, multi – port calling), types of companies (freight forwarders, carrier, NVOCC, etc.); transportation unit loads (e.g. containers) and cost structure of international transportation (ocean freight, additional charges, positioning, detention, demurrage).

2. The Order cycle in a global context. Terms of trade/incoterms, main criteria for the selection of terms of trade and implications on costs structure; analysis of the shipping process in the international context and of examination of the role of main actors (supplier, client, freight forwarders, banks, insurance companies). Customs clearance process and classification of duties.
3. Internationalization process of the distribution channel. General framework for distribution internationalization; main methods for entry in a new market, both indirect exporting (e.g. export trading companies, distributors) and active exporting (e.g. agents, subsidiaries, Ecommerce B2C); main configurations of logistics networks in terms of type of warehouses (e.g. consolidation hub, international warehouse, merge in transit warehouse) and number of echelons; main logistics strategies (i.e. International sale, International outpost and International network).
4. The management of financial flows in a global context. The impact of duties, taxes (e.g. value added tax) and currency fluctuations; the logistics tools for the management of financial flows: VAT warehouses, bonded warehouses, free trade zones (FTZ), triangulations.
5. Logistics outsourcing in a global context, as a strategic lever for internationalization. Study of the main actors and advanced services (e.g. representative office tax, management of logistics flows and payments); the role of 4PL (Four party logistics).
6. The risk management in a global context. Main risk factors in international flows; main approaches towards risk management (buffers tock, contingency plans, mitigation), models to assess global risk, insurance policies to manage the risk.
7. Planning of logistics flows in a global context. The design of relationship between subsidiaries and headquarter (forecasting, replenishment, production planning); setting of a collaborative planning with distributors (VMI on global scale)); advanced planning tools (e.g. DRP); the value and the tools of visibility in a global context.

Bibliography

Main textbooks

David P., International Logistics, Anno edition: 2013, ISBN: 978-0-9894906-0-3

Dornier P., Ernst R., Fender M., Kouvelis P., Global operations and logistics, Editore: John Wiley and sons, Anno edition: 1998, ISBN: 978-0471120360

Hult T., Closs D., Frayer D, Global Supply chain management, Editore: McGraw Hill Education, Anno edition: 2014, ISBN: 978-0-07-182742-3

057125 International Economics I
(5 ECTS credits)

The course is offered in the:

Fall Semester [First Half-semester (Sep – End of October)]

Prerequisites

Polimi Open Knowledge Moocs – Economics → https://www.pok.polimi.it/ or undergraduate level introduction to economics/microeconomics course.

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance;
- Develop new ideas and solutions in business and industrial scenarios evolving over time;
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members.

Expected Learning Outcomes

By the end of the course, students will:

- Have an ability to describe and analyse the main drivers of international trade
- Gain an understanding of the most important models of international trade and be able to use models to make informed predictions
- Be able to critically discuss the empirical validity of these trade models and understand their real-world relevance
- Have the ability to analyse and discuss the underlying factors behind firm-level and country-level patterns of international trade
- Understand the impacts of trade flows on economic well-being, growth, and income distribution

Topics Covered

The course will introduce students to the main international trade models as well as the empirical validity of these models. We will analyse the causes and consequences of international trade. We will study issues, such as: why nations trade, what they trade, and who gains (or not) from this trade, what types of firms' trade. Topics covered will include comparative advantage, gains from trade, the effects of trade on economic growth and wage inequality, multinationals.

Bibliography

No texts suggested.

057161 International Economics II
(5 ECTS credits)

The course is offered in the:

Fall Semester [Second Half-semester (November – End of December)]

Prerequisites

Polimi Open Knowledge Moocs – Economics → https://www.pok.polimi.it/ or undergraduate level introduction to economics /macroeconomics course.

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance;
- Develop new ideas and solutions in business and industrial scenarios evolving over time;
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members.

Expected Learning Outcomes

By the end of the course, students will:

1. Be able to discuss trade policy issues applying the theory to real-world questions
2. Analyse the basic welfare implications of a range of trade policies used by governments
3. Gain an ability to discuss, analyse and apply basic international monetary concepts
4. Understand what factors and mechanisms determine the foreign exchange rates
5. Be able to discuss the link between price levels, output and exchange rates

Topics Covered

This course discusses the economic relationships between countries, covering both trade policy and monetary issues. We will look at the impact of international trade policy, more specifically instruments of trade policy, political economy of trade policy, trade policy in developing countries and controversies in trade policy. The course will also cover topics on exchange rates and open-economy macroeconomics, including national income accounting and the balance of payments, exchange rates, interest rates, price levels and output.

Bibliography

Main textbooks

Krugman P., M. Obstfeld and M. J. Melitz, International Economics: Theory and Policy, Editore: Pearson International Edition, Anno edition: 2018

097374 International Markets and European Institutions
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Knowledge of basic economics principles is strongly suggested to fully benefit from the course. Especially students that did not take a course in Economics in their undergraduate studies are strongly advised to take the online course "Fundamentals of Economics" available on the Politecnico website.

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance;
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment;
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members.

Expected Learning Outcomes

The course will allow students to:

- Understand the functioning of international markets and of the main international institutions;
- Know how changes in the regulations and institutions affect business decision making in an international environment;
- Analyse the international environment to develop adequate solutions to internationalization challenges and opportunities;
- Discuss issues and solutions in international teams.

Topics Covered

1. Introduction to international markets and the role of international institutions.
    - Market failures and externalities in international markets.
    - The role of institutions as public goods.
    - International policies

2. Macroeconomic analysis of the interdependencies between countries
    - Balance of payments and international transmission of policies and shocks
    - Economic growth, development and market imperfections
    - The role of the IMF and World Ban*k*

3. Microeconomic analysis of the interdependencies between countries and the effects of trade liberalization and market integration
- Problems with market access and risks in foreign markets
- Effects of international openness and the elimination of barriers to markets
- Economic policies of integration and protectionism in manufacturing and services

4. The role of the WTO and multilateral agreements between countries
- Multilateral agreements on international trade
- Current functions of the WTO: trade integration, international rules on market access and intellectual property protection.
- The ongoing negotiations within the WTO

5. The basics of the EU integration process
- Short history of the EU
- From the custom union to the single market
- The enlargements and their implications
- EU actors: the community institutions and the national powers

6. Why integrating? Economics of preferential liberalization and regional integration
- Forms of preferential liberalization
- Costs and benefits of preferential agreements between countries: static and dynamic effects of preferential liberalization

7. The European Union integration: rules and policies of the Single Market.
- The main EU policies for the creation and functioning of the Single Market
- EU enlargements and regional policies

8. The European Union monetary integration
- The rational of the creation of the single currency
- Monetary integration and the Eurozone fiscal and monetary policies
- Financial markets integration

9. Recent evolution and the future of the EU

Bibliography

Main textbooks

R. Baldwin and C. Wyplosz, The economics of European integration, Editore: McGraw-Hill, Anno edition: 2015, ISBN: 978-0-0771-6965-7

Addition readings from the EU website and from websites of other international institutions https://europa.eu/european-union/about-eu_en

Recommended materials

World Trade Organization, World Trade Report 2011, The WTO and preferential trade agreements: from co-existence to coherence, Anno edition: 2011

ce - 9: Designing Safer Chemicals)

051112 Introductory Econometrics

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Students should be familiar with basic concepts in probability, statistics and matrix algebra. To be self-contained, the course includes a brief refresher, just in case.

Learning Objectives

This course covers empirical strategies aimed at answering economic research questions. The course illustrates several applied econometric models, and develops the skills needed to plan and carry on empirical research projects. Since most applied economic research examines questions with direct policy or managerial implications, this course will clarify the difference between correlation and causal links. Purely predictive methods, grounded in correlation and regression analysis will be presented and compared with alternative estimation techniques (such as instrumental variables) more focused on the analysis of causal effects. The goal of the course is to provide valuable econometric tools for students majoring in several fields, from micro/macro/international/industrial economics to finance, and management. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

With respect to the first learning goal, at the end of the course students will be able to:

- Understand in depth the key aspects of the linear regression model and the relevance of the underlying standard assumptions
- Understand the variants of the linear regression model to be used when the standard assumptions do not hold
- Understand why the linear regression model is not appropriate when the dependent variable is discrete, truncated or censored and which are the appropriate models to be used in those cases

With respect to the second learning goal, at the end of the course students will be able to:

- Select the appropriate econometric model to be applied in practical economic situations.
- Interpret the output of econometric packages implementing econometric models
- Test the validity of the underlying assumptions for each model
- Use econometric models to support economic decisions

Topics Covered

The agenda includes regression, instrumental variables, differences-in-differences, probit, logit, tobit, survival analysis. One of the goals is to equip students with working knowledge of the tools of probability and statistics, skills in data handling and statistical programming, and an understanding of the models and methods of applied econometrics. To this aim, problem sets with both analytical and computer-exercise components will be a relevant part of the course. The cases will be illustrated and discussed using the open source econometric package Gretl (gretl.sourceforge.net).

Main topics

- Basics refresher: estimation and testing theory, matrix algebra
- The linear multiple regression model under standard assumptions: estimation through Ordinary Least Squares, reading and interpreting the regression output, using the model for prediction.
- Checking assumptions of the regression model: functional form, multicollinearity, heteroskedasticity, autocorrelation, non-normality
- Using the model to investigate causal relationships: omitted variables, endogenous regressors and the method of instrumental variables
- Using the model to analyse the effectiveness of policies and managerial choice: the differences-in-differences method
- Analysis of binary variables (probit and logit models)
- Analysis of categorical variables (multinomial logit models)
- Analysis of ordinal variables (ordered probit models)
- Analysis of count variables (Poisson regression)
- Analysis of truncated and censored variables (Tobit models)
- Analysis of durations (survival model)

Bibliography

Main textbooks

William Greene, Econometric Analysis, 7th Ed., Editore: Pearson, Anno edition: 2012, ISBN: 9780131395381 http://pages.stern.nyu.edu/~wgreene/Text/econometricanalysis.htm
Note: selected chapters

057035 Invest in Foreign Markets Lab

(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

None, but it is recommended that students attend the courses of the International Business Major.

Learning Objectives

The "INVEST IN FOREIGN MARKETS LAB" aims at providing students with theoretical and practical skills to set up, manage and expand a foreign venture.
To reach this goal, students will be involved in theoretical lectures, exercises, case studies, business talks, role plays, and simulations provided by professors from Politecnico di Milano and by Business Executives from Multinational and Consultancy Companies, who will directly transfer their expertise and experience to the Lab participants.
Additionally, students will gain practical skills by taking part into different project works in collaboration with Alibaba, which will allow them to directly apply the knowledge and capabilities developed during the Lab to design a real international business plan for a real company. The project will be developed in teams composed of both students from Politecnico di Milano and students from other universities (working at distance) within the "X-culture" challenge (http://x-culture.org/).
The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modelling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment;
- Develop new ideas and solutions in business and industrial scenarios evolving over time;
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members.

Expected Learning Outcomes

At the end of the course, students will learn to:

- Select the international business strategy that is consistent with the global competitive context;
- Design the international business plan of a company that aims to invest in foreign markets;
- Minimize the cross-border (country and currency) risks;
- Planning a global (out) sourcing venture and managing a strategic partnership;
- Organize a cross-country logistics and transportation;
- Set up an international digital marketing and e-commerce strategy;

- Design an architectural organization that is consistent with the international business strategy;
- Manage the international human resources and deal with multiculturalism;
- Understand how to launch and finance a "born-global" start-up;
- Select the governance programmes supporting the internationalization of the firms;
- Face an interview and a recruiting process in a multinational firm;
- Negotiate the legal framework of an international outsourcing contract;
- Identify the opportunities arising from the partnerships between MNEs and NGOs;
- Interact with the top managers of multinational enterprises and learning from their experience;
- Cooperate and compete with peers to solve an international business project.

Topics Covered

The "Invest in foreign markets Lab" is composed of six modules:

1. International business strategies. Main topics:
   - International business strategies
   - Business plan for international business
   - Offshoring and global (out)sourcing
   - International (digital) marketing strategy
   - Cross-border e-commerce
   - International pricing
   - International entrepreneurship
   - Legal framework for international business negotiation
   - Partnerships between MNCs and NGOs: business opportunities and local development
2. Corporate Finance and financial support for international business: Main topics:
   - Valuation methodologies for cross-border M&As
   - Managing international country risks
   - International funding of SME and international entrepreneurship
   - Government assistance programmes and tools for firms' internationalization
3. International logistics and distribution. Main topics:
   - Entry modes for international business
   - Types of service of the main transportation modes
   - Customs clearance process and classification of duties
   - Role and impact of "special" warehouses: VAT warehouses, bonded warehouses, free trade zones (FTZ)
4. International organization and human resource management. Main topics:
   - The organizational architecture of multinational companies;
   - CEO, Top management teams and internationalization
   - Multicultural team management
   - The recruiting of human resources in multinational companies
5. Meet the managers and visit the company:
   - Meet top managers of MNEs
   - Meet the policy-makers supporting international business
6. Group Project work:

- Participation to real internationalization projects of companies provided by the e-commerce platform Alibaba, which will actively organize and assist students from Politecnico di Milano to design the business plan for the internationalization of some of its customers. The project will be developed in collaboration with "X-Culture" (http://x-culture.org/), an international challenge involving more than 5,000 students from 130 business schools in 65 countries; students will be included in teams composed of about 5 people from different countries working on a real business project of a company provided by Alibaba. Both Polimi and Alibaba tutors will assist the students in developing their project.
- A final presentation of the project is required.

Bibliography

Main textbooks

Charles Hill, Thomas Hult, "International Business: competing in the global Marketplace", Editore: McGraw-Hill Higher Education; 12 edition (February 20, 2018), Anno edition: 2018

Note: The course material will be uploaded either before or immediately after each lecture (based on lecturers' requests). The book is optional.

097391 Investment Banking
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Some knowledge of accounting.

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance;
- Identify trends, technologies and key methodologies in a specific domain (specialization streams).

Expected Learning Outcomes

Students will be able to:

- Understand and explain investment banking activities, discussing features of extraordinary deals (e.g. IPOs, M&A, LBOs, restructuring).
- Frame different solutions (and their suitability and implications) according to corporation needs and market conditions.
- Learn and apply most used methodologies and practices and discuss trends in complex areas of financial management.

Topics Covered

The course focuses on investment banking topics. In particular, it concentrates on the valuation issues through the explanation of the different methodologies developed and used within the industry, along different kinds of deals and needs. In addition, it focuses on the way in which financial intermediaries can arrange and support companies' fund-raising processes on the market and through private placements. Finally, some lectures will provide insights about some extraordinary deals and assets and debts restructuring processes.

The course includes the following lectures:

- Valuation
  - Company value: introduction to equity and enterprise value, aim of valuation
  - Analytical and empirical methodologies: asset approach, earnings approach, cash flow approach, relative valuation approach, mixed methodologies (e.g. EVA)
  - Equity Research
- Capital Markets
  - Debt fund raising: structured bonds, ABS
  - Equity fund raising: private offering and public offering (e.g. SEO). Listing on a Stock market Exchange

    - Project finance
    - Private equity
    - Structured operations: complex derivatives, CDS
    - Corporate Banking: short- and mid-term financing

- Extraordinary deals
    - Mergers & Acquisitions and LBOs
    - Company crises and company restructuring
    - Asset restructuring
    - Debt restructuring

Bibliography

Recommended materials

Joshua Pearl, Joshua Rosenbaum, Investment Banking: Valuation, Leveraged Buyouts, and Mergers and Acquisitions, Editore: Wiley

057051 Knowledge Management in Infrastructure Projects
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

The course aims to equip students with basic knowledge of digital information management systems in the construction sector for architectural and engineering works and infrastructures: fundamentals of BIM (Building Information Management). The training is structured so as to allow the student to understand the main digital information problems, to acquire techniques for an organic approach to their solution, to be able to effectively interact with the technologies and skills involved in the digital management of information during the strategy, design, construction and operation phases. The course provides the student with knowledge about:

1) digital information management flows;

2) digital information management systems and tools;

3) national and international standards of digital information management.

Expected Learning Outcomes

None

Topics Covered

- *Knowledge management & infrastructure projects:* data space and digital platform; knowledge net in construction sector; AI and industry 4.0 in construction sector; Building Information Modelling (BIM)
- *BIM principles and standards:* BIM story; international practice UK and USA; principle of digitization in construction sector; politics and laws for digitization of construction sector*;* International standard ISO; European standard CEN; National standard UNI
- *Digital Information management flow:* actors and organization; strategy and design phase; purchasing phase; construction phase; operation phase (life cycle management). Project, inter and intra organization perspectives for collaboration and data uses.
- *Digital Information management system and tools:* Digital platform for constructions; Common Data Environment (CDE); BIM Authoring 3D tools; Time Management 4D scheduling tools; Cost management 5D tools; Asset management 6D tools
- *Digital information request and delivery:* GIS model for infrastructures, Asset and Project information models; Organization, Asset and Project Information Requirement; Exchange Information Requirement; BIM Execution Plan; Information Delivery Plan
- *Digital information analysis: digital and* circular economy, cost-benefit analysis, market and use value, BIM review tools for clash detection, code and quality checking

Bibliography

Main textbooks

A. Pavan, C. Mirarchi and others (2019), *BIM-Based Collaborative Building Process Management*, Springer, ISBN: 978-3-030-32888-7

052796 Leadership & Innovation
(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Students are required to know the basics of business administration, organizational design and business process management.

Learning Objectives

The goal of the course is to enable students understanding innovation and leadership dynamics in order to act as innovative leaders within and across organizations.

The course offers the opportunity to develop an innovative solution while experiencing team dynamics and interpersonal relationships. Students will face innovation challenges offered by real organizations, to experiment the dynamics of creativity and collaboration while bridging theory and practice.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes and performance
- Develop new ideas and solutions in business and industrial scenarios evolving over time
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

Lectures, activities and team-based projects will allow students*:*

- To know and understand the different strategies to foster the innovation process and their applications (lectures)
- To know and understand the different leadership theories and models to comprehend inter-personal processes (lectures)
- To know how to gather and structure relevant information to deepen the knowledge about the context in which an innovation is taking place (project)
- To develop an innovative vision and propose a solution under different constraints (project)
- To improve collaborative attitudes and know relevant drivers to foster team effectiveness (project)
- To communicate effectively an innovative idea (project)

Topics Covered

The key topics that will be covered in the course are the following, divided in the two main areas:

Innovation

In this module you will learn how to promote and mange innovation with a strategic perspective, as well a show to manage and lead an innovation process. The module focuses especially on the capabilities of leaders to create innovative visions and to catalyse the resources that are needed to make that vision come through and all the phases, activities and methodologies needed to transform and idea into a product-service solution to be launched in the market. The topics characterizing the module are the following:

- What is innovation, what is its value and its challenges
- The drivers and the timing of innovation
- The innovation strategies and the creation of vision: innovation of meaning and design-driven innovation
- Technology strategy: key technologies, dynamic capabilities, complementary assets, profiting from innovation
- Collaborative and Open Innovation
- Guiding principles and models for managing innovation processes
- User's analysis and user's integration in innovation processes

Leadership

In this module you will learn how to develop the capabilities to engage yourself and others in becoming innovative leaders and effectively managing change and innovation in organizational settings. The topics characterizing the module are the following ones:

- What is leadership, what is the difference between leaders and managers
- How to assess people and effectively communicate with collaborators
- The motivational theories that help leaders to trigger others' commitment
- How to design and lead effective teams; teams' roles and dynamics in innovation processes
- Team dynamics: group behaviours, group decision making, conflicts and negotiation
- How to effectively face change and lead innovation in complex organizational settings

Bibliography

Main textbooks

Roberto Verganti, Overcrowded: Designing meaningful products in a word awash with ideas, Editore: MIT Press, Anno edition: 2017, ISBN: 9780262035361

Melissa Schilling, Strategic Management of Technological Innovation, Editore: McGraw-Hill, Anno edition: 2010, ISBN: 978-0078029233

Kreiter R., and Kinicki, A., Organizational behaviour (11th Edition), Editore: McGraw-Hill/Irwin, Anno edition: 2013

096089 Logistics Management
(10 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec) & Spring Semester (Feb – May)

Prerequisites

The Logistics Management Course assumes that students have a basic knowledge of Production and Logistics Planning Models (Demand Forecasting, Inventory Management, Production Planning). Students that do not have this basic knowledge will be provided with references and material (e.g. slides, MOOCS) to fill the gap.

Learning Objectives

This course aims to provide the main methodologies and criteria for analysing, designing and managing Logistics Systems and Processes. After an overview on the strategic importance of Logistics and on the Performance Measurement Framework, the course addresses the 3 main layers of Logistics Management: Execution, Advanced Planning, System Design. The last section of the course is dedicated to Innovation in Logistics. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

1. Understand and describe:
   - The main logistics strategies and their consistency with the general company strategy
   - The main logistic solutions in the fields of distribution, warehousing (storage and picking), transportation, inventory management
   - The main models/methodologies that are intended to convey the key principles and criteria to design and manage logistics systems
2. Apply the theories, models, principles and criteria to solve complex "likely logistics problems" and to understand and address "real-world logistics problems"
3. Design and illustrate innovative logistics solutions in new fields (e.g. B2c eCommerce)

Topics Covered

1. The strategic role of **Logistics Management**. Definition of Logistics Management. Evolution of the concept of Logistics. Logistics and Supply Chain Management. The 3-layer model: execution, planning, design. The role of Logistics in the corporate strategy. Types of Logistics Strategies.

2. **Logistics Performance Measurement System.** Logistic costs measurement and analysis. Customer service KPIs. “Cost-Service” relationship.
3. **Logistics Execution.** Warehouse Design and Management: objectives, criteria, methodologies, quantitative decision-support models. Automated warehouses: performance indicators, technical features, management policies, application fields, design methods. Order Picking: technological solutions, design methods, management policies. Transportation Management. Transportation modes (road, ship, train, air, multimodal/intermodal): features and application fields. Optimization of road transportation.
4. **Advanced Inventory Planning.** Inventory planning in a multi-item multi-node logistic system. Collaborative Planning: Information sharing, Central coordination models (e.g. Vendor Managed Inventory -VMI), Collaboration models (e.g. Collaborative Planning Forecasting and Replenishment-CPFR). Impacts of inventory management on order cycle time.
5. **Logistics System Design.** Logistic network design and management. Distribution network typologies: single and multi-echelon, hub and spoke, mixed structures. Design methodologies and quantitative decision support tools. Outsourcing of Logistics: objectives, logistic service providers, selection criteria.
6. **Innovation in Logistics.** eCommerce and Omni-channel Logistics. Logistics 4.0. Sustainable Logistics. Reverse Logistics.

The Logistics Management course leverages the following teaching methodologies:

- Theoretical lessons, i.e. “traditional” lessons to provide the students with both a deep knowledge on logistics systems/processes and criteria, methodologies, models, tools to design and manage logistics systems (Intended Learning Outcomes - ILOS - 1, 2, 3)
- Practical lessons, i.e. lessons going through structured exercises to let the students apply what they learnt during the theoretical lessons (ILOS 2, 4)
- Seminars. i.e. lectures given by external guests (top managers from multinational companies) to provide the students with strong connections with the real applications of what has been learnt during the lessons (ILOS 1, 2, 3)
- Virtual/real visits, i.e. in-class (with videos) and or in-company visits to show the students the logistics systems and processes of multinational companies (ILOS 1, 3, 4)

Bibliography

Recommended materials

Coyle, Langley, Gibson, Novack, Bardi, Supply Chain Management: A Logistics Perspective. (from 8th edition, 2008), Editore: South-Western College Publications, ISBN: 9780324376920

Ballou, R.H., Business Logistics Management (from 5th Edition, 2003), Editore: Prentice Hall, ISBN: 9780130661845

Chopra S., Meindl P., Supply Chain Management: strategic, planning and operation, Editore: Prentice Hall, Anno edition: 2004, ISBN: 0131217453

058324 Machine Learning

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Machine Learning is a discipline at the interface between mathematics and computer science. Hence, a good background in probability, linear algebra and calculus is required, as well as a programming experience.

Learning Objectives

This course gives an overview of techniques and algorithms in machine learning and pattern recognition. It provides students with the basic ideas and intuition behind modern machine learning methods as well as a more detailed coverage of most techniques.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

By the end of the module, students should:

- Have a good understanding of the fundamental issues and challenges of machine learning: data, model selection, model complexity.
- Develop an appreciation for what is involved in learning from data.
- Understand a wide variety of machine learning algorithms.
- Understand how to apply a variety of learning algorithms to data.
- Understand how to perform evaluation of learning algorithms and model selection.
- Understand the strengths and weaknesses of many popular machine learning approaches.
- Appreciate the underlying mathematical relationships within and across machine learning algorithms and the paradigms of supervised and unsupervised learning.
- Apply the algorithms to a real-world problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models.
- Be able to design and implement various machine learning algorithms in a range of real-world applications.
- Be able to write code in Python programming language to use machine learning algorithms.

Topics Covered

- Introduction to Machine Learning

Motivations of machine learning. Machine learning, artificial intelligence and big data. Applications of machine learning. Representation of input data. Machine learning process.

- Exploratory data analysis

Data validation and cleansing, outlier and missing values detection. Data transformation. Data reduction. Sampling. Feature selection. Features extraction by filtering. Principal component analysis. Data discretization. Univariate analysis: graphical analysis, measures of central tendency, dispersion, relative location, heterogeneity, analysis of the empirical density. Bivariate analysis: graphical analysis, measures of correlation, contingency tables. Multivariate analysis: graphical analysis, measures of correlation.

- Supervised learning: classification and regression

Taxonomy of supervised methods. Evaluation of classification models: holdout, cross-validation, confusion matrix and derived metrics, ROC curve, cumulative gain and lift. Treatment of categorical attributes. Nearest neighbour. Classification and regression trees: splitting, stopping and pruning. Bayesian methods: naive methods, Bayesian networks. Logistic regression. Neural networks: Rosenblatt perceptron, multi-level feed-forward networks. Support vector machines: structural risk minimization, maximal margin hyperplane for linear separation, nonlinear separation. Simple and multiple linear regression. Assumptions on residuals. Least square regression: normality and independence of residuals, significance of coefficients, analysis of variance, coefficients of determination and linear correlation, multicollinearity, confidence and prediction limits. Selection of predictive variables. Ridge regression. Generalized linear regression.

- Association rules

Motivation and evaluation of association rules. Single-dimension association rules. Apriori algorithm. Generation of frequent item sets, generation of strong rules. General association rules.

- Clustering

Taxonomy of clustering methods. Affinity measures. Partition methods: K-means, K-medoids. Hierarchical methods: agglomerative methods, divisive methods. Evaluation of clustering models.

- Applications and use cases

Introduction to Python programming language and its main libraries for machine learning (Scikit-learn, Keras). Applications in relational marketing using Python: lifetime value analysis, acquisition, retention, cross-selling, market basket analysis. Web mining. Social market analysis. Speech recognition. Text mining. Fraud and anomaly detection. Bioinformatics.

Bibliography

Main textbooks

C. Vercellis, Business intelligence: data mining and optimization for decision making, Editore: Wiley, Anno edition: 2009

Recommended materials

T. Hastie, R. Tibshirani, and J. Friedman, The Elements of Statistical Learning, Editore: Springer, Anno edition: 2011

E. Alpaydin, Introduction to Machine Learning, Editore: MIT press, Anno edition: 2014

A. Geron, Hands-On Machine Learning with Scikit-Learn and Tensorflow: Concepts, Tools, and Techniques to Build Intelligent Systems, Editore: O'Reilly, Anno edition: 2017

057031 Macroeconomics of Finance

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Students should know fundamentals of microeconomics and macroeconomics theory. Whenever those were not acquired previously, the MOOC "Economics" should be followed and successfully completed.

Learning Objectives

The course will provide students with models to understand how (and why) money and financial variables matter from a macroeconomic perspective. The importance of credit and financial market imperfections for the conduct of monetary policy and for real economic activity will be stressed. At the end of the course the student should be able to understand macroeconomic stabilization policies, the main monetary policy operating procedures, the role of financial intermediation and the effects of financial fragility on the economic system. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

The student:

- Understands the financial/monetary context and knows how the different transmission mechanisms of financial/monetary shocks to the real economy operate;
- Knows which are the implications and the possible evolving trends of imperfections in credit markets on firms' borrowing possibilities and, in general, on the macroeconomic outcomes;
- Knows how to design new economic scenarios and/or the effects of monetary policies on economic agents' behavior by simplifying and proper modeling the economic context;
- Can identify the effects of financial fragility on the economic system.

Topics Covered

The aim of the course is to stress the importance and the effects of financial choices and of monetary policy decisions on real economic activity. After introducing some basics macroeconomic concepts, useful to understand the real effects of economic policies and the functioning of monetary policy, we study credit market imperfections and how they can cause financial fragility phenomena that can lead to financial and real crises.

Main topics
Block 1. Basic macroeconomic concepts (neo-classical model, IS-LM model, the liquidity trap, the AD-AS model, the Phillips curve, the yield curve);
Block 2. Monetary policy operating procedures (the money multiplier, the central bank balance sheet, the *ECB's* monetary policy c*orridor*, the Taylor rule, inflation targeting, post-crisis non-conventional policies);
Block 3. Asymmetric information and financial intermediation; credit market imperfections and their effects on economic activity [from Modigliani-Miller to the financial hierarchy; credit rationing: Stiglitz e Weiss (1981), bank runs and financial panics: Diamond e Dybvig (1984)];
Block 4. Financial fragility and monetary policy transmission mechanisms to real activity (the traditional interest rate channel (money view), asymmetric information effects and the credit channel (*credit view*): lending view (Bernanke and Blinder (1988)) and the financial accelerator).

Bibliography

Main textbooks

Blanchard, Amighini, Giavazzi, Macroeconomics-A European Perspective, Editore: Pearson

Xavier Freixas, Jean-Charles Rochet, Microeconomics of Banking

057021 Management for Sustainability and Impact
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Fundamentals and basic concepts of management.

Learning Objectives

This course is designed to provide students with concepts and instruments that are necessary to gain a better understanding of sustainability and impact management. The course offers a new perspective on the whole set of managerial notions and concepts that students already master, ranging from strategy to technology management, accounting and financing, in light of sustainability-oriented entrepreneurial models and economic paradigms. The course focuses on new market paradigms, corporate models and entrepreneurial forms that are designed to generate a positive social and environmental impact and to find suitable solutions to emerging challenges. The program includes the analysis of strategy, technology and impact management, financial instruments, accounting and control tools, performance management approaches as a function of the objectives of newly established social ventures or consolidated and mainstream corporate models, striving to exploit the opportunities related to emerging societal challenges. The successful completion of the course enables students to interpret the complex ad systemic relationships between environmental and societal challenges, technological innovation, market disruption and purpose-driven corporate and entrepreneurial models.

In particular, the course contributes to the development of the following capabilities:

- Understanding the concept of impact and sustainability management and the foundations of purpose-driven corporate and entrepreneurial models. The distinguishing feature of such models is the proactive pursuit of solutions to social and environmental problems along with economic sustainability and profit;
- Designing innovative solutions through the application of scientific approaches (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face societal and environmental challenges and seizing related opportunities, developing system-changing ideas, scaling solutions and translating them into long-term oriented, sustainable business models;
- Interpreting real-world situations and learning from case studies;
- Interacting in a professional, responsible, effective and constructive way in a working environment, also motivating group members.

Expected Learning Outcomes

Upon completion of the course, the main expected learning outcomes are:

- Understanding the concept of impact and sustainability and the entrepreneurial responses to new societal challenges and opportunities, in the realm of inclusive economy;
- Understanding the fundamentals of social innovation and its practical applications;
- Interpreting the whole system of managerial notions that students are already provided in a purpose-driven perspective;

- Designing social ventures' business models and developing related managerial strategies;
- Mastering competencies and tools necessary to face the managerial challenges that are typical of purpose-driven companies;
- Understanding the role of technological innovations to spark systemic change in social business models and purpose-driven companies;
- Mastering concepts and tools to measure a firm's performance in terms of the social and environmental impact generated;
- Understanding the different forms of financial approaches and instruments that are designed to deliver social and environmental impact along with financial returns;
- Learning how to scale social ventures and purpose-driven companies through ESG and impact finance;
- Developing communication skills and communicate the key concepts in a public context as well as in a written document (in-class case discussion and written and oral exam).

Topics Covered

1. **The Emergence of the Impact Imperative**

   The current trends and societal challenges and the quest for a new capitalism

   The fundamentals of Social Innovation: theory and practice

   Understanding and interpreting the fundamentals of social and environmental impact

   The role of technology and innovation in the impact revolution

2. **The Entrepreneurial Dimension of Social Innovation: Organizational Challenges and Strategies**

   Combining profit and purpose: a definition and taxonomy of hybrid organizations

   The legal framework for impact-oriented hybrid organizations

   Purpose-driven corporations and corporate strategies for sustainability

   Business models for impact venture and purpose-driven corporations

   Scaling impact ventures

   Technology, innovation and management of Social-Tech Ventures

   Measuring and managing social and environmental impact

3. **Finance for Sustainability and Social Impact**

   The emergence of novel purpose-driven financial approaches

   Disintermediation, ethics, and values: alternative finance models

   Applying ESG criteria for long-term risk protection: responsible finance

   Environmental and value-based financial approaches and instruments: sustainable finance

   Investing in solutions: microfinance and impact finance

Bibliography

Main textbooks

A Primer in Social Innovation
Note: During the course, a Primer will be provided as well as additional readings and case studies.

057019 Management of Energy
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

The course aims at providing knowledge, skills and tools needed for analysing, understanding and assessing strategic decisions about energy management. The course provides students with methods and tools to analyse the context, understand the main trends and phenomena affecting the energy industry, assess the different alternatives a company has in the management of energy, in the light of the ongoing decarbonization path. The course starts by providing a global framework of the energy sources and uses and of the strategic role of energy and sustainability for firms. Then, it focuses on the market and industry dynamics related to "traditional" sources (oil&gas), as well as renewable energy sources (such as photovoltaic and wind energy). Energy efficiency and the emerging paradigms of energy communities, smart buildings and cities and smart mobility are further investigated. The role of technological innovation and regulatory framework in the above-mentioned industries is assessed, to provide students with a comprehensive view of the phenomena.

The discussion of business cases and examples, together with the presence of presentations by executives and managers, will encourage students to examine and get familiar with the abovementioned topics as well as their strategic and practical implications. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, global framework, market and industry dynamics in the energy field and their mutual effects on business, economy, environment and society
- Identify trends, technologies, key methodologies and stakeholders needs in the energy domain.

Expected Learning Outcomes

Students will:

- Understand and interpret the role of energy management in the current competitive environment and its evolution
- Understand the market and industry dynamics in the energy industry
- Understand the impact of the technological innovation and of the regulatory framework in the energy field
- Apply the appropriate tools to analyse the competitive environment in the energy industry
- Identify the critical decisions in the management of energy by firms
- Discern and select the appropriate strategic approaches to energy management
- Identify the main opportunities to launch new businesses in energy domain

Topics Covered

1. **Basics of energy & sustainability**. Energy sources and uses at global level; Top Countries in production and use of energy; The sustainability concept in the energy domain and related regulatory provisions; Emission Trading Scheme (ETS).
2. **The electricity industry.** Electricity industry value chain; Electricity markets overview; Power generation technologies: technical and economic performances; Economies of Networks.
3. **Market and industry dynamics in the Oil&Gas sector**. Global Market dynamics; Technologies & Business Models (Revenues, Margins, Organization) in the oil&gas industry; Analysis of top players at global and European level; Decarbonization trends in the Oil&Gas industry.
4. **Market and industry dynamics in the renewable energy sector**. Global Market dynamics; Renewable energy technologies overview (e.g., PV, Wind, Hydropower); The evolution of the regulatory framework in Europe related to energy production from renewable energy sources and its impact on industry dynamics; Existing and emerging Business Models (Revenues, Margins, Organization) in the renewable energy industry (e.g., Power Purchase Agreement).
5. **Market and industry dynamics in the energy efficiency sector**. Global Market dynamics; Energy efficiency technologies overview (e.g. electric engines, VSDs, building insulation) for buildings and industrial processes. The evolution of the regulatory framework in Europe related to energy consumption and energy efficiency (incentives, obligations, certifications) and its impact on industry dynamics; Existing and emerging Business Models (Revenues, Margins, Organization) in the energy efficiency industry (e.g., Energy Performance Contracts).
6. **Smart Ecosystems**. The role of digital technologies in the energy domain; Integrating new technologies for producing, using and storing energy in local environments (energy communities) as well as in building and cities (smart buildings and cities). Business cases and examples of energy communities and smart buildings.
7. **E-mobility.** Emerging trends (e.g., electrification, sharing, autonomous driving) that are reshaping "traditional" mobility towards "smart mobility"; e-mobility enabling technologies overview (e.g., e-cars, charging infrastructure); the evolution of the regulatory framework in Europe related to electric vehicles and its impact on industry dynamics; Existing and emerging Business Models (Revenues, Margins, Organization) in the electric vehicles charging services (e.g., Charging Point Operators, Mobility Service Providers).

Bibliography

No texts suggested.

054202 Manufacturing Systems Engineering I
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Short Description

The course provides a framework, quantitative methods and competences to design manufacturing systems and to manage their continuous modification in coordination with the evolution the mix of products they produce and the change in the manufacturing processes they implement. Methodologies to jointly consider the set of tangible and intangible aspects that concur to the configuration and reconfiguration decisions, methodologies that allow to cope with uncertainty in future scenarios and methodologies for the optimal configuration of manufacturing systems are proposed. The methodologies and tools studied in the course are applied within a Project lab to a realistic case study. The Project lab is part of the innovative didactics program of Politecnico di Milano.

054952 Manufacturing Systems Engineering II
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

The design and management of production systems asks for methods devoted to the performance evaluation and optimization of system configuration and control. In the scope of the framework provided by Manufacturing Systems Engineering I, this course deals with mathematical models of manufacturing systems aimed at evaluating the performance and optimizing the configuration and control of manufacturing systems. Different mathematical models will be studied and applied based on the characteristics of manufacturing systems.

The goals of the course are:

- Identify trends, technologies and key methodologies in the industrial domain
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modelling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

The methodologies studied in the course will be applied within the Project lab to a real case study. The Project lab is part of the innovative didactics program of Politecnico di Milano.

Expected Learning Outcomes

After passing the exam, the student will be able to:

- Analyse production problems and devise the requirements for manufacturing systems;
- Develop models of manufacturing systems based on a mathematical representation of their characteristics and behaviour and according to the required level of detail;
- Identify, select, and manipulate mathematical methodologies to support the design, management and control of manufacturing systems;
- Design the configuration and control of manufacturing systems and estimate their performance.

After completing the Project lab, the student will be able to:

- Write a technical project report;
- Present the results achieved during the analysis, modelling and testing activities.

The course is based on lectures, classwork, project lab and optional activities. Guest international speakers will be invited to give special lectures. The Project lab is part of the innovative didactics program of Politecnico di Milano.

Topics Covered

Technical design of Manufacturing systems. Relations between technological specifications and production system types. State-based modelling of manufacturing systems. Continuous-time Markov chains to model simple manufacturing systems. Analytical methods (queueing networks) to model complex productions systems and estimate key performance indicators. Approximate analytical methods to model unreliable manufacturing systems and evaluate their performance. Decomposition techniques to evaluate the performance of long flowlines.

Design of Manufacturing Systems Control. Optimization of token-based production policies. Hedging point policies.

Analysis of real production systems.

Bibliography

Main textbooks

Professor's notes: page on BeeP platform https://beep.metid.polimi.it/web/108910323

A. Di Gennaro, A. Giua, Sistemi ad eventi discreti, Editore: McGraw-Hill, Anno edition: 2002, ISBN: 88-386-0863-6
Note: suggested pages: 83-129

D.D. Yao, Stochastic Modeling and Analysis of Manufacturing Systems, Editore: Springer Verlag New York, Anno edition: 1994, ISBN: 3-540-94319-6
Note: suggested pages: 1-13

J.A. Buzacott, J.G. Shanthikumar, Stochastic Models of Manufacturing Systems, Editore: Prentice-Hall, Anno edition: 1993, ISBN: 0-13-847567-9
Note: suggested pages: 365-377

S.B. Gershwin, Manufacturing Systems Engineering, Editore: Prentice-Hall
Note: suggested pages: XVII-XIX; 1-18; 59-99

057027 Marketing Analytics

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Solid background in statistics is particularly useful. Basic knowledge of SQL and R or similar languages and/or of statistical tools and software (e.g., SPSS, Stata, etc.) may facilitate the learning process.

Learning Objectives

The course intends to introduce top-notch analytical approaches for data-driven marketing. The course will adopt a hands-on approach based on a recursive pattern:

- Introduction to the marketing problem to be addressed through analytics
- Introduction of the analytical/statistical method(s) suited to solve the problem
- Practical application of the method(s) and exercises
- Discussion of the actual adoption of the method(s) in practice

Expected Learning Outcomes

- Understand challenges, functions, processes in a business and industrial environment and their mutual effects on business, economy, environment and society
- Identify trends, technologies, key methodologies and stakeholder needs in analytics for business
- Interact in a professional, responsible, inclusive, effective and constructive way in a working environment, also motivating group members

Topics Covered

1. Introduction to marketing analytics: the need for a data culture in marketing, the data available for marketers and the ability to read them effectively
2. Segmentation: mathematical and statistical methods. Cluster analysis, ANOVA, factor analysis and discriminant analysis. Cases and interpretations
3. Data mining for marketing and CRM: SQL basics, the use of queries to support CRM decisions and applications for market basket analysis
4. Stochastic modelling in marketing: the case of customer lifetime value (CLV)
5. Advanced CRM analytics: survival analysis for churn prediction and prevention
6. Advanced marketing analytics: attribution modelling in omnichannel, multi-touchpoint contexts and marketing mix modelling (marketing effort optimization)

Bibliography

Main textbooks

Stephan Sorger, Marketing Analytics: Strategic Models and Metrics, Editore: Admirall Press, Anno edition: 2016

Blanchard, Debasish, Pranshu, Data Science for Marketing Analytics: Achieve your marketing goals with the data analytics power of Python, Editore: Packt Publishing, Anno edition: 2019

Hermann, Burbary, Digital Marketing Analytics: Making Sense of Consumer Data in a Digital World, Editore: Que Publishing, Anno edition: 2018

056818 Methodologies for Life Cycle Thinking

(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

The goal of the course is to provide future engineers with the required technical and scientific knowledge for assessing the sustainability of production processes and sanitary and environmental engineering technologies with a life cycle approach, in order to support the achievement of UN SDGs (Sustainable Development Goals) number 11 “sustainable cities and communities” and number 12 “responsible production and consumption” All three dimensions of sustainability - environmental, economic, and social - will be addressed.

Students will be provided with the necessary skills to study the impacts that industrial activities have on ecosystems, on the availability of natural resources, and on human health. They will learn to break down complex systems and processes into elementary units, and to analyse and solve problems related to the interaction between technosphere and environment, examining the alternative solutions to choose the most sustainable.

Expected Learning Outcomes

The students will:

- Know and understand the fundamentals of the environmental Life Cycle Assessment (LCA) methodology
- Know and understand the fundamentals of the Life Cycle Costing (LCC) methodology
- Know and understand the fundamentals of the social LCA (SLCA) methodology
- Be able to apply this knowledge in application exercises
- Be able to apply the LCA methodology to simplified industrial cases studies
- Be able to identify the most sustainable solution
- Acquire the ability to communicate their findings

Topics Covered

- Industrial ecology definition, introductory concepts, and principles
- The Life Cycle Thinking principle and initiatives at the national, European and worldwide level
- Environmental Life Cycle Assessment (LCA): historical background, standards, methodology, impact assessment, application to products, application to services (e.g. treatment of solid waste), communication of the results
- Environmental labels
- Life Cycle Costing: methodology and application
- Social LCA: methodology and application
- Sustainability assessment: definition, databases, and technical software
- Link between LCA and circularity assessment

Theoretical lessons will be integrated by the discussion of case studies, the analysis of scientific works, some practical exercises, and the demonstration of specialized software, in order to bring out the relationships between theoretical aspects and operational reality.

Bibliography

Recommended materials

Michael Z. Hauschild, Ralph K. Rosenbaum, Stig Irving Olsen, Life Cycle Assessment: Theory and Practice, Editore: Springer, Anno edition: 2018, ISBN: 978-3-319-56474-6 https://www.dbooks.org/life-cycle-assessment-3319564757/

057203 Methods for Engineering Design

(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

The course is aimed developing the student's design critical skills and synthesis ability, by introducing, discussing and applying the innovative methodologies for engineering design, and by the development of engineering system.

Expected Learning Outcomes

The students will get the critical skills to understand and correctly apply the engineering design methods that consider the complete product lifecycle, starting from the customer requirements to the end of life. They will develop the knowledge and expertise to correctly identify and apply the right engineering design methods with respect of the product of interest through the development of theoretical concepts and their critical application in a practical case study.

Topics Covered

The course deals with the design methods used in the different phases of development of the products and their practical implementation in engineering design. It is a mix of frontal lectures, interactive practical exercises and autonomous development of a real case. Seminars by design engineers coming from industries are also scheduled during the course.

Subjects

Introduction to Engineering Design. From customer requirements to production: concept, embodiment, detail design. The role of codes and standards in Engineering Design: Design by Rules and Design by Analysis.

Design methodologies

Design for Assembly (DfA) Assembly efficiency. Joints for plastic and metal parts: screws, press-fit, rivets, snap-fit. Critical evaluation of the assembly method in the overall design process with respect of performance and cost.

Design for Manufacturing (DfM) – Methods to assess the cost related to manufacturing and to orient to correct choice of the process. The case of injection molding. Introduction to Design for Additive Manufacturing.

Design for Environment (DfE) – The natural and the industrial product life cycles; conditions for sustainability. Life Cycle Analysis (LCA): a) the functional unit, the reference flow and the eco-indicator concepts, b) goal and scope definition, inventory, assessment of the EI, interpretation of the results. Implementation of DfE and LCA in the product design.

Design for Disassembly (DfD) - Choice of materials: the concept of Material Removal Rate (MRE), Architecture of the system and component design, joining methods. New methods for active disassembly (smart materials).

Design for Maintenance and Reliability - Basic concepts, corrective and predictive maintenance, improving the reliability of systems. Risk Analysis: Failure Mode and Effects Analysis (FMEA), Failure mode, Effects and Criticality Analysis (FMEA), Fault Tree Analysis (FTA).

Design optimization and Robust Design – Basic concept.

Practice – During practice time students will be requested to solve problems and exercises about the subjects of the course. A part of the practices is dedicated to a project to be developed in group where the students are requested to develop the design of an engineering system.

Bibliography

Main textbooks

Karl T. Ulrich, Steven D. Eppinger, Product Design and Development, Editore: McGraw-Hill, Anno edition: 2015, ISBN: 9780070658110

G. Boothroyd, P. Dewhurst, W. Knight, Product Design for Manufacturing and Assembly, Editore: Marcel Dekker Inc., Anno edition: 2002, ISBN: 9780824791766

055895 Metodi e Modelli matematici per l'Ingegneria (🇮🇹)

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Basic mathematical knowledge acquired in the first university courses of Linear Algebra and Differential and Integral Calculus is necessary.

Learning Objectives

The teaching is part of the course of study by pursuing some of the general learning objectives declared. In particular, teaching contributes to the development of the skills of:

- Design solutions by applying the scientific and engineering approach (learning, reasoning and modeling based on a solid multidisciplinary preparation) in addressing problems and opportunities in the corporate and industrial fields.

In fact, in the applications of various disciplines (engineering, physics, economics, etc.) problems often arise that have similar characteristics and properties, such that they can be treated with general methodologies of mathematical analysis and functional analysis. The objective is then to provide the student with adequate techniques for modeling and a unified approach to solving these problems. In particular:

1. "variational methods" are developed that are appropriate for studying optimization problems in which the variable quantity is a function or a curve (e.g., the function could represent the evolution of the state of a continuous-time dynamical system);
2. models relating to concrete case studies are formulated and solved in which the aforementioned calculation techniques are applied. The models discussed concern various disciplines such as engineering (production, inventories, maintenance,...), economics (trading, consumption,...) and physics.

Expected Learning Outcomes

Student are expected to:

- understands and knows the fundamental principles and techniques of Calculus in infinite-dimensional vector spaces;
- understands the logical process with which, given a real problem, a simplified model is formulated which captures the essential aspects while neglecting the secondary details;
- is able to autonomously apply the mathematical methodologies learned to the resolution of the model under examination;
- knows how to discuss the results obtained in light of the simplifications considered, proposing any generalizations or variations of the model.

Topics Covered

1. Optimization in functional spaces.

- Classical problems: geodesics on the plane, geodesics on the sphere, geodesics on the cylinder, Dido problem, rotation surface of minimum area, brachistochrone.
- General formulation of an optimization problem: functionals and Lagrangian; Normed spaces and comparison functions; admissible variations; global extremants and local extremants (strong or weak).
- Free optimization. Variational Taylor formula (at first order) and first variation of a functional; extremal. Fundamental problems: first and second Euler-Lagrange equations; regular and broken extremals (Hilbert criterion; Erdmann-Weierstrass conditions). Convex functionals and convexity criteria.
- Constrained optimization (inequality constraints; isoperimetric constraints). Extension method. Lagrange multiplier method.
- Applications (model formulation and its resolution): rotation surface of minimum area; brachistochrone; equilibrium configuration of a suspended cable; optimal production plan; better navigation route; optimal fault control program; optimal consumption plan.

2. Excellent control.

- General formulation of a continuous-time control problem: cost or performance index, states and state equation, controls and admissible controls; excellent control.
- Normal problems. Adjoint variable and adjoint problem, Hamiltonian; Pontryagin condition and extreme controls. Convexity criterion; criterion of the test function. Optimality principle.
- Applications (model formulation and its resolution): optimal maintenance program; optimal inventory plan; optimal buying and selling plan.
- Optimal feedback controls: optimal controls and initial conditions; the Hamilton-Jacobi-Bellman equation.
- Applications (model formulation and its resolution): improved navigation route; horizontal flight of a rocket.

Bibliography

Recommended materials

Teaching notes: Available on WeBeep course web page

052079 Mobility: Infrastructures and Services

(8 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

This course provides the students with the basic elements in the field of land mobility systems management focusing mainly on systems for people and with references to the transport of goods.
The course starts with the analysis of the demand for mobility and the importance of the integration between different modes of transport and with the description of the transaction from transport service to mobility service.
The second part of the course refers to existing rail and road infrastructures highlighting technical specifications, regulatory framework, safety, management, maintenance and diagnostic, planning and design.
The third part of the course focuses on the transport services on different levels with the addition of basic elements of travel management, maintenance and diagnostic of the rolling stock, rail and road services for passengers and freight.
The last part of the course deals with future mobility scenarios, considering both industry and the provider of mobility.

Expected Learning Outcomes

The goal is to open the mind of the student in the field of mobility engineering.
After completing the course, the students are able to:

1. Know the basic terms and principles of transportation systems
2. Discuss issues related to transportation systems in technical and scientific meetings
3. Read and understand technical documents related to planning and operation of transport systems
4. Roughly identify the principles useful for obtaining solutions to problems of transporting people and goods

Different projects developed during the course in cooperation with companies enable the students to experience the mechanisms of teamwork while final presentations in front of the rest of the class and an audience of experts improve communication and public presentation skills.

Topics Covered

Topic 1: The demand for mobility and system integration.
Topic 2: From transport services to mobility services.
Topic 3: Rail infrastructures.
Topic 4: Road infrastructures.
Topic 5: Stations as intermodal-hubs.
Topic 6: Long hall services in Europe.

Topic 7: Local public transport.
Topic 8: Transport planning.
Topic 9: Freight transport.
Topic 10: Future mobility scenarios.

Bibliography

No texts suggested.

090037 Model Identification and Data Analysis

(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

- Familiarity with basic concepts of computer science (algorithms and complexity) and dynamical systems theory.
- Mathematical maturity in linear algebra and probability theory.

Learning Objectives

The goal of the course is to enable students to extract ("learn") from measured data useful information. The course covers advanced topics of data-driven black-box system identification and virtual sensing.

Expected Learning Outcomes

Through theoretical lectures and numerical-exercises sessions, the students are expected to:

- Understand the fundamental problems that can be encountered while extracting information from a finite set of observations taken from an unknown system.
- Learn the main tools of system identification and virtual sensing.
- Be able to formulate identification problems corresponding to different applications.
- Understand a range of algorithms along with their strengths and weaknesses.
- Be able to apply suitable algorithms to solve application problems.
- Be able to read current research papers and understand the issues raised by current research in the field.

Topics Covered

The program of the course is as follows.

Part 1:

- Basic concepts of stochastic processes
- ARMA and ARMAX classes of parametric models for time series and for Input/output systems
- Parameter identification of ARMA and ARMAX models
- Analysis of identification methods
- Model validation and pre-processing

Part 2:

- Non-parametric system identification: the subspace-based state-space approach
- Kalman Filter: prediction, virtual-sensing and grey-box system identification
- Analysis and design of closed-loop systems using the minimum-variance approach
- Non-linear system-identification: parametric nonlinear fitting; N-ARMAX models; optimal design of basic functions using Principal-Component-Analysis
- Frequency-domain parametric estimation of models from data

- Recursive system identification: extension of system-identification to time-varying systems

Bibliography

Main textbooks

S. Bittanti, Model Identification and Data Analysis, Editore: John Wiley, Anno edition: 2018, ISBN: 9781119546368

S. Bittanti and S.M. Savaresi, Lecture notes

Recommended materials

P. van Overschee, B.L. de Moor, Subspace Identification for Linear Systems: Theory, Implementation, Applications, Editore: Kluwer Academic Publishers, Anno edition: 1996
ftp://ftp.esat.kuleuven.be/pub/SISTA/ida/reports/96-26a.pdf
Note: Freely available online.

L. Ljung, System Identification: theory for the user (II ed.), Editore: Prentice-Hall, Anno edition: 1999

T.S. Soderstrom, P.G. Stoica, System Identification, Editore: Prentice-Hall, Anno edition: 1989

056988 New Forms of Organization

(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Students are expected to know the key principles of organization design, leadership and innovation.

Learning Objectives

The goal of the course is to provide students with the understanding of future work and organizations scenarios and to enable them to design new forms of work and organization that are aligned with the new competitive and social environment, exploiting the opportunities offered by digital technologies. In particular, the course will contribute to the following Learning Goals:

- Identify future trends, technologies and key methodologies in a specific domain (work and organization design)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modelling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

Lectures and case discussions will allow students to be able to:

- Understand the future of work and organizations scenarios
- Analyse the changes in the society and the competitive environment that influence work and organizations
- Appraise the challenges and opportunities offered by digital technologies in designing work and organizations
- Appraise the main characteristics of emerging organizational models and the new approaches to organizational innovation
- Design new forms of work and organization
- Be an effective leader in the new organizational scenarios
- Apply people management practices that are aligned with the new organization models
- Drive organizational change

Topics Covered

The course covers the main challenges and future scenarios of work and organizations, the main characteristics of emerging organizational models and the new approaches to organizational innovation. All the topics are treated both theoretically and through company cases and testimonials. An elective project work is also foreseen for students that want to go more in depth on some of the models presented in class.

The course will cover the following topics:

- Emerging challenges for the future of work and organizations: society, competitive environment, new digital technologies
- Future scenarios of work and organizations
- The Agile Organization:
  - Agile principles
  - The Agile organization in practice: tools and methods
  - People leadership and management in agile organizations
- The boundary-less organization:
  - From outsourcing to crowdsourcing
  - Platform work and organizations
  - People leadership and management in boundaryless organizations
- Smart and virtual work
  - Smart and virtual work principles, methods and tools
  - People leadership and management in smart and virtual work context
- The purposeful organization
  - The role of purpose in new forms of work and organization
  - People leadership and management in purposeful organizations
- Organizational innovation and change
  - New approaches to organizational innovation and change
  - Agile and design thinking principles for organizational innovation

Bibliography

No texts suggested.

057055 Omnichannel Marketing Management

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Knowledge of the marketing process, background in accounting/finance/control and in strategic planning

Learning Objectives

The course is an advanced marketing course, with a special focus on the challenges and the opportunities introduced by the availability of different channels of interaction with the customers (both B2B and B2C).

The goal is to introduce tools and methods for omnichannel marketing management, share and nurture a natively omnichannel, customer-centric approach for marketing, and provide tools to design omnichannel marketing actions

Expected Learning Outcomes

- Understand challenges, functions, processes in a business and industrial environment and their mutual effects on business, economy, environment and society
- Identify trends, technologies, key methodologies and stakeholder needs in analytics for business
- Develop new ideas and transformative solutions to deliver positive impact on business, industrial and societal scenarios evolving over time
- Interact in a professional, responsible, inclusive, effective and constructive way in a working environment, also motivating group members

Topics Covered

- The evolution of customer behavior and the interaction between individuals and channels.
- Omnichannel vs multichannel marketing
- Customer journey mapping and the personas method to enrich segmentation and targeting
- Customer insight development
- Designing an omnichannel branded experience
- Omnichannel campaign design
- Post-purchase experience: Customer Relationship Management and customer lifetime management
- Omnichannel marketing operations: Search Engine Optimization and Marketing, communication planning, campaign management and eCommerce marketing
- Metrics for omnichannel marketing
- The marketing and communication ecosystem and latest developments in omnichannel marketing (e.g., eGames, influencer marketing)

Bibliography

Main textbooks

Palmatier, Sivadas, Stern, El-Ansary, Marketing Channel Strategy: An Omni-Channel Approach, Editore: Routledge, Anno edition: 2019

Kotler, Katrajaya, Setiawan, Marketing 4.0: Moving from Traditional to Digital, Editore: John Wiley & Sons, Anno edition: 2016

096088 Operations Management

(10 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec) & Spring Semester (Feb – May)

Prerequisites

The following prerequisite are not mandatory (their knowledge can be acquired alongside attending the course) but the following knowledge increases significantly the benefits obtainable through this course

Basic knowledge of Organization theory and design

Basic knowledge of cost accounting (fix costs vs variable cost; investment evaluation; interest rate on a loan)

Basic knowledge of statistics

Learning Objectives

The objective of the course is to provide students with principles, methodologies and tools to design, analyse and improve manufacturing and service companies' operations, so to dramatically increase their competitive advantage. Students will learn to deal with the multidimensional aspects of Operations at a strategic, tactical and operational level. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
- Develop new ideas and solutions in business and industrial scenarios evolving over time

Expected Learning Outcomes

The student successfully taking this course is expected to be able to:

- Classify the different Operations Systems
- Understand the functioning of such systems
- Match the system characteristics with its target market segment
- Generate alternative guidelines to improve the system, considering main goals, constraints and evolutionary trends
- Design and implement solutions to improve the Operations System through a thorough methodology, sound reasoning and, whenever possible, quantitative analysis
- Check whether the results are in line with the expected ones and the goals achieved

Topics Covered

Introduction

- Operations' objectives and decision areas.

- Operations in primary processes, and in supporting processes. Operations in industrial companies and in-service companies.

Operations strategy
- Operations performances, levers, positioning
- Development of an operations strategy in the broader context of a Business strategy considering the different areas of Operations in an integrated way
- Structural decisions (resources sizing, system configuration, vertical integration, system international footprint, etc.) and Infrastructural decisions (resource planning and control, organizational structure, target setting, customer management)

Service Operations Management
- Distinctive characteristics of service companies. The service concept definition.
- Designing, managing and improving the Service delivery system. Front office versus back office, demand and capacity management. Demand management in service companies with fixed capacity (Hotels, Airlines, Tourist villages...) Yield management.
- Queue theory. Single and multiple customer-class systems; single and multiple resource systems.
- Operations in different service industries

Operations improvement: innovative managerial approaches for operational excellence-
- Lean philosophy and principles. Analysis of innovative aspect of Lean approach that allow to achieve such dramatic improvements. Going beyond Just In Time.
- Lean methodologies and techniques: Value Stream Mapping. Variations reduction. 5S, SMED, Cell design, etc.
- A new vision of human factor and the impact on operations' structure.
- Advanced implementation of Lean approach: high variety low volume companies, make to order / engineer to order companies (manufacturing and services). Lean product development, Lean Healthcare, Lean Banking, Lean Insurance.
- Lean Supply Chain: the impact of applying the Lean philosophy to the whole supply chain.
- Lean consumption.
- Leading an Operational excellence project. Building a continuously improving and problem-solving Organization.
- Systems thinking
- Lean and Industry 4.0

Bibliography

Main textbooks

N. Slack, A. Brandon-Jones, R. Johnston, A. Betts, Operations and process management., Editore: Pearson ed. 4th

Recommended materials

J. Bicheno, A. Portioli Staudacher, Metodologie e Tecniche per la Lean, Editore: Pitagora
J. Womack, D. Jones., Lean thinking, Editore: Free press, Anno edition: 2003
J. Liker, The Toyota Way, Editore: McGraw Hill, Anno edition: 2005
Terry Hill, Alex Hill, Manufacturing Strategy, Editore: Palgrave Macmillan, Anno edition: 2009

097321 Operations Risk Management and Resilience
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

This course aims at providing the student with fundamental criteria, processes and methods to manage operational and supply chain risks in uncertain business contexts and achieve operational resilience against unexpected disruptions. The student will learn and apply different risk modelling and analysis techniques, both qualitative and quantitative, in relation to specific application contexts. A clear understanding of the peculiarities and relevance of adopting risk-informed or resilience-driven decisions, at both strategic and operational level, is achieved through class discussion of real cases in different industrial sectors and seminars from industry managers.

Expected Learning Outcomes

After successful completion of this course the student:

- Will demonstrate the ability of classifying and modelling different risk sources in operations and supply chains, eventually selecting sound mitigation strategies (Knowledge and understanding);
- Will be able to select and apply proper qualitative and quantitative risk assessment methods (Applying Knowledge and understanding);
- Will be able to identify and critically discuss emerging relevant ORM&R challenges, leveraging on state-of-the art knowledge (Making Judgements and Learning skills), and editing a final report on the subject matters (Communication).

Topics Covered

The course covers the following topics:

Introduction to Operations Risk Management. Operations strategy and Operations Risk Management (ORM). Classifications of operational risks. Integration of Operations Risk Management and Enterprise Risk Management. The Risk Management Process (ISO31000). Risk homeostasis.

Quantitative and Qualitative Risk Assessment. Anatomy of risk (the risk concept and fundamental definitions). Reference Risk Identification and Assessment Methods (ISO31010). Application of Monte Carlo Method to operations risk analysis.

Supply Chain Risk Management. Vulnerabilities of global Supply Chains, the case of COVId-19 pandemic. Operational and disruption risks in Supply Chains. Supply and Supplier Risk Management: Business Impact Analysis of supplier disruptions; FMECA-based supplier assessment; risk-based supplier segmentation. Risk mitigation strategies and the role of digital technologies. Exercises and discussion of cases.

Operational & Supply Chain Resilience. Core resilience functions and resilience capabilities. Business Continuity Management. The influence of Operations strategies and Supply Chain complexity on resilience. Business game and discussion of cases.

The learning experience of this course includes, in addition to face-to-face lectures, numerical exercises, case discussions, a group project, real examples and interactions with guest speakers from industry. Groups of students (max 3) will be engaged in a major assignment focusing on either a state-of-the-art review paper or an ex-post analysis of a supply chain disruption event. The final report will be part of the student assessment process (see next paragraph).

Bibliography

Main textbooks

Course instructor, Teaching notes, Case texts and suggested readings
Note: Available on Beep course web page

Recommended materials

Waters D., Supply Chain Risk Management: vulnerability and resilience in logistics, Editore: KoganPage, Anno edition: 2011
Sheffi, Y, The Resilient Enterprise, Editore: The MIT Press, Anno edition: 2005

056992 Patents and Intellectual Property Management
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

The course is designed to provide engineering students with in-depth skills on Industrial Property (IP) management, with a focus on patents.

The course includes four parts:

1. Part one (30%) focuses on the explanation of the economic and legal rationale of IP and describes the various protection mechanisms available at the Italian, European and extra-European level, highlighting the main international differences.
2. Part two (30%) focuses on the procedures to obtain IP protection. This part includes a series of practical exercises, such as prior art searches and studies of the freedom to operate.
3. Part three (30%) focuses on the strategic aspects of IP management, providing students with a current and far-reaching view on strategies for managing single IPs and portfolios. The course continues with the strategies currently used by companies in different types of industries, with a focus on open and semi-open patent strategies and the related business models. The course will touch upon the global trends in infringement and counterfeiting.
4. Part four (10%) deals with the techniques for evaluating and pricing patents in different circumstances and for different purposes

Expected Learning Outcomes

Applied knowledge and understanding:

- Knowing the economic and legal rationale of Intellectual Property.
- Knowing how to read a patent, understanding what technological solutions are protected.
- Knowing how to identify the most suitable procedure to obtain the desired patent coverage based on the set objectives.
- Using international databases to carry out basic patent searches, reconstruct prior art and determine freedom of operation.
- Understanding the strategies of IP management and their suitability to fit various types of competitive context.

Autonomy of judgment:

- Taking decisions regarding the deposit, maintenance and granting of IPs.
- Knowing how to read a patent evaluation, discussing its reliability and any areas of uncertainty.

- Knowing how to make adequate decisions regarding the management and enhancement of patents based on the competitive context and business strategies.
- Knowing how to manage a patent portfolio, considering the strategic priorities of a company.

Topics Covered

PART ONE

- What are patents. The economic and the legal-procedural point-of-view.
- IP rights (patents, utility models, plant varieties, trademarks, copyrights, design and other IPs). The requirements (novelty, inventive step, industriality, sufficient description).
- The patenting procedure (filing, examination, extension, granting, opposition, maintenance) of the UIBM, EPO, PCT and the main international differences.

PART TWO

- The patent document: how it is drafted, how it is read and the relationship between writing and legal effectiveness.
- Patent intelligence laboratory: using patent databases to carry out anteriority and freedom of operation searches.

PART THREE

- Patent licensing and the transfer of innovations.
- The management of IP. Strategic uses of patents in business practice. Closed, semi-closed and open strategies: when to use them and how to pair them with business models that monetize the IP value.
- IP violations: counterfeiting, piracy and infringement.
- Patent portfolio management strategies with practical applications.

PART FOUR

- Methods, circumstances and reliability of IP assessments.

Bibliography

Slides and readings https://beep.metid.polimi.it
Note: Slides, reading, and recording of the lectures provided by the instructors

058359 Platform Thinking

(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Suggested pre-requisite (for students which are not enrolled in the M.Sc. in Management Engineering). Strategy MOOC on the POK platform: this course introduces the key theories, concepts, models and approaches related to Strategy at a Corporate, Business and Functional/Operational level. (Available at: https://www.pok.polimi.it/courses/course-v1:Polimi+STR101+2017_M9/about).

Learning Objectives

Thinking about platforms we tend to consider as the "usual suspects" like Airbnb, Uber, Facebook, and so on, digital companies that are often based on a light-asset structure and that mainly enable connections, exactly like Uber or Airbnb. Still, they are not the only companies that (successfully) managed to use the logic of platforms.

Nevertheless, the power of platforms can go much beyond those cases. Think about companies in heterogeneous industries and with very different histories, like John Deere, Telepass, or Poste Italiane, that managed to find new innovative pathways… through platforms. This course aims to let you learn (also) from them!

The course is built on two main steps: using platforms as lenses to read the world around us and to find idle assets, resources, and skills within your organization, and then using Platform Thinking to identify innovative directions through "platform-enabled" opportunities! The course has a strong "hands-on" approach being built around three workshops to apply the Platform Thinking process to an established company to foster innovation through platforms.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies, and key methodologies in a specific domain
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

In terms of Platform Thinking, students will learn to:

- Identify socio-economic mega-trends related to digital platforms, innovative business model and data-driven opportunities [Individual essay]
- Identify platforms models and their peculiarities in the reality around us, going beyond the shiny and apparent face of the usual big names in the platform world [Individual essay]
- Run an analysis of an established company to identify idle asset that can represent an innovation opportunity through a platform model [Teamwork/Workshops]
- Apply the Platform Thinking process to identify and exploit innovation opportunities [Teamwork/Workshops]
- Design a platform-based business model and a transformation roadmap for an established organization [Teamwork/Workshops]

Topics Covered

Overview of the Course:

Over the last two decades, platforms have transformed the way, we search for information (e.g., Google), buy goods (e.g., Amazon), consume news and media (e.g., Facebook and Twitter) and travel and move around (e.g., Airbnb, Booking.com, Uber and TripAdvisor). More broadly how we live our everyday life.

This phenomenon is known as 'the power of platforms', defined as an innovative business model that relies on digital technologies to assemble people, knowledge and companies in an interactive ecosystem where value can be created, captured and shared. These platforms have a great ability to attract funds and grow rapidly, relying on external resources (e.g. private houses for Airbnb or private cars for Uber), with a significant impact on the market. These companies act as intermediaries, attempting to reduce frictions in the market and helping the supply and demand sides of a product or service to find each other.

As such, existing companies may be inspired by these fast-growing companies to at least partially capture the opportunities underpinning the model. Most of them are digital companies mainly focusing on the service field; nevertheless, recent cases show how platforms are having an impact in many different industries with the spread of the sharing economy and implications in the brick and mortar industries.

Still, we don't believe that platforms are only for the digital world, for start-ups or for ventures created in the Silicon Valley. We do believe that platforms are a powerful tool to foster innovation for every kind of organization - a new one, but also for established organizations - wherever they come from, anywhere in the world and focusing on digital or also physical assets.

The course is based on two main pillars:

- Reading: the chance to develop the ability to assess the reality around us, understanding the differences that platforms have in comparison to traditional linear value chain organizations, and more importantly to assess the various meanings (and typologies of businesses) that stay behind the wide label "platforms"
- Writing: the chance to use those concepts and mechanisms to foster innovation, by designing platforms and highlighting the necessary steps to make the platform real.

Main Topics

Hence, the course covers the following main topics:

- The typologies of platforms (transactional, orthogonal, client-as-a-target, client-as-a-source)
- The characteristics of platform organizations (idle asset hunting attitude, pricing strategies, ...)
- The design variables of platforms (double value proposition, the role of trust, the role of personalization, the chicken and egg paradox)
- The data opportunities related to platforms (Business model transparency, data driven epiphanies, data driven innovation)
- The opportunities for an established organization (the idle asset canvas, the evolutionary matrix, ...)
- Technological trends for platform businesses (blockchain, metaverse, web3, ...)
- The challenges of platform management (privacy issues, sustainability dimensions, ...)

Educational Process

The course is based on a heterogeneous teaching approach, aimed at create a continuous debate on the world of platforms and helping students in developing a strong critical thinking attitude to consider both the bright side and the challenges of these organizations.

- The learning experience is characterized by various collaborative and different teaching approaches:
- Blended class (through MOOCs)
- Various international guests (live and recorded interviews)
- Hands-on experience through 3 collaborative workshops
- Critical reading of platform-related news

During the course, students will apply the Platform Thinking process (in 3 workshops) to foster innovation in a real established organization based on a traditional linear value chain, the process is based on:

- Assessment of the established company (Value map and Business Model Canvas)
- Identification of the innovation opportunities (Idle Asset Canvas)
- Platform Ecosystem design (Platform Thinking Canvas)
- Roadmap definition
- Each member of the class will be assigned through a collective workshop to self-managed learning team. During one of the first class, students will be asked to participate in a collective workshop to form the groups. The teams will work throughout the course.

Sustainable Development Goals (SDGs)

This course contributes to achieve the following Sustainable Development Goals:

- **SDG9 - INDUSTRY, INNOVATION AND INFRASTRUCTURE**

The course is completely based on the fact that established organizations have idle assets that could exploited through Platform Thinking, generating more value out of existing resources. Moreover, it focuses on platform-enabling technologies that are the center of the industrial and innovation debates. For these reasons the course is completely (50 hours) focused on the SDG9 Industry, Innovation and Infrastructure.

Bibliography

Main textbooks

Daniel Trabucchi; Tommaso Buganza, Platform Thinking - Read the past. Write the future. Innovate the present., Editore: Business Experts Press, 2023

Recommended materials

Sébastien Ronteau; Laurent Muzellec; Deepak Saxena; Daniel Trabucchi, Digital Business Models - The New Value Creation and Capture Mechanisms of the 21st Century, Editore: De Gruyter, 2022, ISBN: 9783110762556

057022 Policy Design and Evaluation
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No previous knowledge is required. Notions on Public Management can facilitate the learning process.

Learning Objectives

The Policy Design and Evaluation Course prepares students to face the complexity of our society and the policy making processes, in designing innovative public policies and projects and in the evaluation of their results and impacts.

The possibility to achieve sustainable development and fight environmental, economic, technological and social problems is linked to the ability to innovate. For many of the most severe problems it is often hard to find appropriate solutions, but, even when the solutions are available, the ways through which they can enter the public agenda, to be adopted and to be implemented, are full of twists and bumps.

The focus of the course is, then, to present concepts, frameworks and tools to address the question of how it is possible to design policies/projects and their decisional processes able to overcome the obstacles likely to arise in the attempts to introduce an innovation in the solution of collective problems.

The participants will be asked, mainly, to put themselves in the shoes of a policy innovator who tries to design and steer a proposal through the complexities of public policy making. In this path, the policy evaluation concepts and methodologies will add some of the necessary theoretical instruments to the design processes.

The course aims to offer a learning experience that does not try to simplify the complexities of public policy making, nor to provide ready-to-use solutions to the design problems. On the contrary it will stimulate the participants to analyse every single case and to derive a first-hand experience of the different elements which compose the conceptual framework developed by the literature and that represents the more realistic description of how public policies and innovative solutions come about.

A relevant goal of the course is to use different teaching and learning activities:

- In presence and on-line lessons, but reduced in comparison with the traditional courses
- The planning of some module/seminars with foreign professors; to improve contents and results of the course, a cooperation with USA and European teachers is under definition, with the aim to cover specific sectors (eg. environmental, social innovation, digital and technological policies) and – when possible – to interact also with the foreign students of the invited teacher classes;
- The use of an Educational Digital Game, to foster students' engagement/motivation, interaction with the teachers and among students, the use of concepts in cases based on empirical situations; the Game will be played by groups of 5-6 students each;

- The realization of a group project work on a specific theme selected in cooperation with external institutions/stakeholders

Expected Learning Outcomes

The successful completion of the class will allow the student to:

- Understand the characteristics and constraints of policy making processes in pluralistic contexts and in addressing complex collective problems with innovative problem definition and solutions;
- Use the analytical tools learned in class in designing appropriate ways and strategies able to overcome the obstacles to introduce innovations in complex organizational contexts;
- Developing the capacity to connect the theoretical concepts with concrete and empirical 'down-to-the-earth' situations; to accomplish this objective an original educative digital game will be used, developed by Politecnico di Milano (P-Cube game);
- Developing the comprehension of different possible positions through the interaction in groups in an international class

Topics Covered

The core of the course regards the strategies that an innovative designer (public or private) can use in a policy design process able to secure the success of a reform/innovation project.

More generally, the course focuses attention on innovations in broad sense, covering fields such as social innovation policies, digitization policies, innovative urban manufacturing, etc. The post-Covid-19 period offers many examples.

The intent is to use analytic concepts and tools to improve managerial capacity for successful changes in dealing with organizational and societal problems.

The analytical framework developed by policy analysts is useful to help both public and private managers in dealing with complex problems, i.e. issues in which there are different, possibly competing, points of view, lack of all the necessary resources, conflicts.

The class will be organized as follows:

- Introduction: what is a public policy, the foundations of the discipline; the policy design process and its relations with the design thinking approaches
- Problem setting and problem solutions: starting the policy design process
- The evaluation dimensions; improving evaluation capacities in the design process
- The decision-making process: models (rational, bounded rationality, incrementalism, garbage can), elements (the actors and their roles, resources, content of the decision, patterns of interaction, environment), strategies for successful decisions; exercises with the P-CUBE Educative Digital Game
- Policy instruments
- Behavioural assumptions in designing policies and intervention: the causal mechanism approach
- Evaluating policy success and failures: methodological designs

Bibliography

Main textbooks

Bruno Dente, Understanding Policy Decisions, Editore: Springer, Anno edition: 2014, ISBN: 978-3-319-02520-9

Note: English Version; see: Italian Version: Bruno Dente, Le decisioni di policy, Editore: Il Mulino, Anno edition: 2011, ISBN: 978-88-15-23242-7; Spanish Version: Joan Subirats & Bruno Dente, Decisiones Pùblicas, Editore: Ariel, Anno edition: 2014, ISBN: 978-84-344-0996-5

Eugene Bardach - Eric M. Patashnik, A Practical Guide for Policy Analysis: The Eightfold Path to More Effective Problem Solving (6th ed), Editore: CQ Press, Anno edition: 2021, ISBN: 978-1-4833-5946-5
Note: Also, previous edition is accepted

097394 Power Production from Renewable Energy

(8 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

The knowledge of the system configurations and the operating principles of the main power cycles fed by fossil fuels is fundamental. These concepts are provided by the Conversion of energy, Energy conversion and Energy Systems LM courses.

Learning Objectives

This course is dedicated to students with a thorough knowledge of energy issues, and it aims at explaining the various technologies available for the production of electricity from renewable sources. The course deals with a topic of great interest and relevance, from the technical and engineering point of view: producing electricity from renewable sources is becoming increasingly important in a short-medium term scenario, characterized by the need to drastically reduce greenhouse gases and dependence on fossil fuels. The approach to topics is primarily theoretical, in order to understand the physical principles that are at the basis of operation of the different technologies. It also discusses some technological aspects more closely linked to the industrial manufacturing processes, together with the associated economic, managerial, strategic, as well as those related to the environmental impact. The course will provide the students with the technical skills to operate in the field of power plants fed by renewable sources: from decision-making skills required in the design phase, to the technical knowledge related to the operation and maintenance of plants.

Expected Learning Outcomes

- The student will be able to understand the physical working principle and main industrial manufacturing processes of a renewable technology.
- The student will be able to assess the potential energy production and costs of a renewable source.
- The student will be able to understand the energy and environmental balance of power plant based on a renewable source, considering its environmental impact and avoided emissions and energy saving in an LCA perspective.
- The student will be able to understand the part load operation of a renewable plant, and to evaluate the main performance indexes related to an annual operation.
- The student will be able to make a preliminary design of a power plant based on a renewable source, assessing both its economic feasibility and environmental benefits, in terms of avoided emissions and energy saving.
- The student will be able to correctly operate a renewable plant in terms of optimized schedule and forecasting, dispatching electricity and maintenance operations.
- The student will be able to autonomously manage the design choices concerning the construction and operation of renewable source plants.
- The student will be able to communicate the results of his / her activity in a clear and effective way.

Topics Covered

Introduction and perspectives. The potential of renewable energy. Classification of sources and typical problems related to their exploitation for the production of electricity on an industrial scale. Adopted incentive schemes. Current situation and forecast scenarios.

Wind energy. Betz theory and laws of operation, types of machines, applications. Sizing criteria, plant regulation and characteristic curves. Coupling with the generator, power electronics for rotor speed control. Characterization of the wind resource of a site, analysis and profitability of a wind farm. Environmental impact of wind power installations. Off-shore wind farms. Small and micro-wind.

Geothermal energy. Classification of geothermal sources: liquid and vapor-dominated hydrothermal source, hot dry rocks. Exploration techniques and drilling. Adoptable power plants: direct steam cycle, plant with flash and separation of steam, binary ORC cycles. Cogeneration plants. Design aspects, issues related to geothermal fluids and environmental impact.

Energy from biomass. Classification of biomass and future potential. Conversion systems with grate boilers: water steam cycles and ORC. Flue gas treatment systems. Anaerobic digestion for biogas production. LCA analysis applied to the cycle of biomass.

Solar energy. Solar radiation: characteristic angles and the solar spectrum. Instruments for measuring radiation.

Photovoltaic solar energy: the photoelectric effect, processes for silicon production and photovoltaic cell manufacturing, electrical characteristic of the cell and circuit connection, inverter and power conditioning systems. Design criteria for off-grid and grid-connected plants. Thin-film and multi-junction cells, recent technological developments. Concentrating photovoltaic.

Concentrating solar power: classification of concentrating systems. Parabolic-trough collectors, parabolic dish systems, Fresnel collectors, central receiver systems. Thermal performance of a collector, selective coatings. Heat transfer fluids and thermal storage tanks. Sizing of a solar power plant. Operating strategy of a plant and estimation of the yearly production.

Energy from small-hydro plants. Classification of plants and hydraulic machines. Future potential of the resource. Design criteria of a run-of-river hydroelectric plant, regulation. Environmental impact.

Energy from the sea. Introduction to the classification of available technologies or pre-commercial devices: energy from currents, wave, tidal, systems based on the thermal gradient of oceans (OTEC). Integration with desalination plants.

Bibliography

Recommended materials

G. Boyle, Renewable Energy, Editore: Oxford, Anno edition: 2014
A. Da Rosa, Fundamentals of Renewable Energy Processes, Editore: Elsevier, Anno edition: 2012, ISBN: 978-0-12-397219-4 http://www.sciencedirect.com/science/book/9780123972194
John F. Walker, Nicholas Jenkins, Wind energy technology, Editore: John Wiley & Sons
A. Luque, S. Hegedus, Handbook of Photovoltaic Science and Engineering, 2nd edition, Editore: Wiley

John A. Duffie, William A. Beckman, Solar Engineering of Thermal Processes, 4th Edition, ISBN: 978-0-470-87366-3
Ronald Di Pippo, Geothermal Power Plants: principles, applications and case studies, Editore: Elsevier
Lorenzo Battisti, Gli impianti motori Eolici, Editore: Green place energies
Daniele Cocco, Chiara Palomba, Pierpaolo Puddu, Tecnologie delle energie rinnovabili
Andrea Bartolazzi, Le Energie Rinnovabili, Editore: Biblioteca tecnica Hoepli

097357 Power Production from Renewable Energy C
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

The knowledge of the system configurations and the operating principles of the main power cycles fed by fossil fuels is fundamental. These concepts are provided by the Conversion of energy, Energy conversion and Energy Systems LM courses.

Learning Objectives

This course is dedicated to students with a thorough knowledge of energy issues, and it aims at explaining the various technologies available for the production of electricity from renewable sources. The course deals with a topic of great interest and relevance, from the technical and engineering point of view: producing electricity from renewable sources is becoming increasingly important in a short-medium term scenario, characterized by the need to drastically reduce greenhouse gases and dependence on fossil fuels. The approach to topics is primarily theoretical, in order to understand the physical principles that are at the basis of operation of the different technologies. It also discusses some technological aspects more closely linked to the industrial manufacturing processes, together with the associated economic, managerial, strategic, as well as those related to the environmental impact. The course will provide the students with the technical skills to operate in the field of power plants fed by renewable sources: from decision-making skills required in the design phase, to the technical knowledge related to the operation and maintenance of plants.

Expected Learning Outcomes

- The student will be able to understand the physical working principle and main industrial manufacturing processes of a renewable technology.
- The student will be able to assess the potential energy production and costs of a renewable source.
- The student will be able to understand the energy and environmental balance of power plant based on a renewable source, considering its environmental impact and avoided emissions and energy saving in an LCA perspective.
- The student will be able to understand the part load operation of a renewable plant, and to evaluate the main performance indexes related to an annual operation.
- The student will be able to make a preliminary design of a power plant based on a renewable source, assessing both its economic feasibility and environmental benefits, in terms of avoided emissions and energy saving.
- The student will be able to correctly operate a renewable plant in terms of optimized schedule and forecasting, dispatching electricity and maintenance operations.
- The student will be able to autonomously manage the design choices concerning the construction and operation of renewable source plants.
- The student will be able to communicate the results of his / her activity in a clear and effective way.

Topics Covered

Introduction and perspectives. The potential of renewable energy. Classification of sources and typical problems related to their exploitation for the production of electricity on an industrial scale. Adopted incentive schemes. Current situation and forecast scenarios.

Wind energy. Betz theory and laws of operation, types of machines, applications. Sizing criteria, plant regulation and characteristic curves. Coupling with the generator, power electronics for rotor speed control. Characterization of the wind resource of a site, analysis and profitability of a wind farm. Environmental impact of wind power installations. Off-shore wind farms. Small and micro-wind.

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Energy from the sea. Introduction to the classification of available technologies or pre-commercial devices: energy from currents, wave, tidal, systems based on the thermal gradient of oceans (OTEC). Integration with desalination plants.

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A. Luque, S. Hegedus, Handbook of Photovoltaic Science and Engineering, 2nd edition, Editore: Wiley

John A. Duffie, William A. Beckman, Solar Engineering of Thermal Processes, 4th Edition, ISBN: 978-0-470-87366-3
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Lorenzo Battisti, Gli impianti motori Eolici, Editore: Green place energies
Daniele Cocco, Chiara Palomba, Pierpaolo Puddu, Tecnologie delle energie rinnovabili
Andrea Bartolazzi, Le Energie Rinnovabili, Editore: Biblioteca tecnica Hoepli

097327 Product Life Cycle Management

(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

This course does not require any specific prior knowledge of the topic.

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

The aim of the course is to introduce students to the basic concepts of Product Lifecycle Management (PLM) and life cycle thinking. The acronym PLM enables a holistic life cycle-oriented way of thinking through a set of principles, methods and tools supporting a more effective and efficient management of the life cycle stages of industrial products, from their design/engineering, to production, distribution, usage until disposal/end of life.

In its comprehensive meaning, PLM is a business approach based on collaboration and integration of people, processes and technologies, which aims to support the development of more innovative, reliable and sustainable solutions (products and services) in a shorter time.

From a *managerial perspective* PLM encompass (i) a strategic management point of view where the product is the enterprise value creator; (ii) the application of a collaborative model for the empowerment of the core competences distributed along the different actors involved in the lifecycle (e.g. designers, engineers, manufacturers, suppliers, etc.); (iii) the adoption of a number of IT solutions for establishing an access-safe product information management environment. From a *technical perspective*, PLM is a matter of methods, standards and techniques for structuring the engineering processes, as well as a matter of computer-based tools for enabling virtual prototyping and collaborative workspaces. Lean product and process development is a paramount support for the effective understanding and accomplishment of the above-mentioned points and will play an important role, not only as topic of discussion taught within the course, but also used to generate within the students' critical attitude towards problem understanding and problem solving.

The aim of the PLM course is to introduce students to the concepts and elements of PLM and lean product and process development, from a managerial and a technical perspective, giving also the basics to run the introduction of PLM (as approach, models, methods, and tools) in the industrial practice, approach problems and process improvement via lean thinking, with the ultimate purpose to develop a life cycle thinking attitude into the students.

Expected Learning Outcomes

Expected results from Product Life Cycle Management Class are:

- **Understand** - provide students with the prevalent knowledge in the field of PLM and Life Cycle Thinking from a theoretical and practical side to show how these aspects reflects on real business. The students are expected to gain general knowledge on PLM and life cycle thinking.
- **Identify** - students, will gain general knowledge needed to understand PLM, and will be provided with specific knowledge on trends and approaches existing in effective and advanced PLM implementation solutions from industry, such as lean product and process development. Students will be expected to be able to identify how specific approaches enable and impact life cycle thinking within enterprises. In the specific lean product and process development as an overall and growing body of knowledge will be taught to the class that is expected to acquire deep knowledge on that.
- **Design** - most importantly, students will be provided with the ability to acquire and develop a critical thinking attitude in business process understanding and problem solving. This will be achieved through a continuous link between in class theoretical applications and real-world applications, as well as challenges proposed to students to be addressed in class via exercises, serious games, projects and teamwork activities. The ultimate purpose is to make this class not as the arrival learning point for these concepts, but to be the starting platform to build and link what has already been learned and what needs to be learned in the future to address growing business needs-by applying either what has been introduced in this course or learnt somewhere else - enable a relentless life cycle thinking mindset.

Topics Covered

The PLM course is a mix of frontal lectures, industrial cases, interactive class exercises, and serious games. Course topics include:

- Life cycle thinking, product life cycle management, product life cycle phases
- Innovation, New Product Development Process and Concurrent Engineering
- Lean Product and Process Development
- The Front-End Process
- Design Methods (Design for Manufacturing and Design for Environment)
- Value and Function Analyses (QFD & VA/VE)
- Prototyping, Examples from Virtual Prototyping and CAD tools
- Process Mapping and mapping application case
- Collaborative Platforms (PDM & PLM)
- PLM system and PLM system implementation
- PLM Projects Evaluation. Application case
- Introduction to sustainable product development and circular economy
- Set-Based Concurrent Engineering (SBCE) Game
- Life Cycle Perception Game

Class attendance is not mandatory, though encouraged. All material will be provided digitally on line (Beep). Supporting books and references will also be suggested throughout the course. In-class exercises and teamwork will be used to facilitate advanced learning of PLM material and concepts. The final exam will be a 1,5-hour written test; oral exams will be allowed only to students that receive a 27 or higher grade on the written test.

Bibliography

Recommended materials

Ulrich and Eppinger, Product Design and Development
Note: 5th edition

Rossi, Morgan, Shook, The Routledge Companion to Lean Management - Lean Product and Process Development Chapter, Anno edition: 2017

John Stark, Product Lifecycle Management, Editore: Springer, Anno edition: 2012
Note: 2nd edition

057030 Project Management
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

Large complex projects are the key elements of our time; they are needed to plan and deliver infrastructure, address a global pandemic like COVID-19, or deal with climate change. Large complex projects span across industries and economic sectors, including the development of new major software, aerospace and military systems, but also humanitarian projects. This course aims at transferring to students theoretical and practical knowledge about Project Management, Business, and Ecology. The key goals are enabling students to:

- Understand the Project Management, Business and Ecology, its peculiarities, stakeholders and intra/interdependencies
- Evaluate complex projects and programmes according to key elements such as budget, scope, schedule, stakeholders, risks and financing.
- Develop project delivery models considering the different dimensions of success and sustainability

Expected Learning Outcomes

After successful completion of this module students:

- Will gain a holistic understanding of project business and project ecology
- Will be able to understand key project management concepts, their evaluation and application
- Will be able to select and apply proper qualitative and quantitative project management tools, processes and methods at the different project and system life cycle stages
- Will be able to critically assess projects and programmes considering scope, risk, stakeholders, sustainability
- Will be able to propose delivery models considering the different dimensions of project success.

Topics Covered

The course addresses the state-of-the-art approaches, methods and models for deciding, planning, and delivering complex projects and programmes. Including traditional "Project Management" topics, the course covers the essentials of project business (e.g. the governance of the organizations involved in projects) and the most recent elements of the project ecology. More specifically:

- Introduction to Complex Project Business and Project Ecology: Introduction of key concepts such as project, programme, portfolio, project-based company. Managing for stakeholders, stakeholder's relationship maps, project governance and project Ecology
- Traditional project Management model, tools and techniques: Scope management including WBS and other structures, Project life cycle and S curves (with numerical

exercises), Economic and Financial (with exercise on NPV, IRR, Project Balance), Critical Path Method and its limitations (with numerical exercises), Resource Scheduling (with numerical exercises), Project Controlling and its implications for re-planning.

- Project delivery models: Risk Management (definition, identification, evaluation, mitigation, contingency, reporting), Bidding and Contracting, Sustainability (including SDG) & Dark side (modern slavery, corruption, sexism etc.), Project management success vs project success

This module's learning experience includes face-to-face lectures, numerical exercises, case discussions, real examples, and interactions with guest speakers from the industry.

Bibliography

Main textbooks

Teaching notes, scientific papers, Case texts and suggested readings by the instructor (available on Beep course web page).
“Project Management: Achieving Competitive Advantage” by Jeffery Pinto, Pearson; 5th edition, 2019.

059115 Public Management
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

The main objective of the course is providing a picture of the challenges for managing public organizations, also by explaining similarities and differences with the management of private companies. The program starts with a description of the relevance of public sector, then illustrates the economics and managerial theories about its role in the economy.

The main conceptual effort in the first part of the Course will be devoted to the evolution from traditional (bureaucratic) Public Administration to modern Public Management principles. The second main part of the program is devoted to analysing how the "hard" tools of management should be applied to the public sector: strategic planning, performance management, digital innovation and use of data.

Expected Learning Outcomes

- Learning the characteristics of public sector
- Applying the managerial techniques to public organizations
- Evaluating the performance of public organizations
- Understanding how innovation shapes the public sector

Topics Covered

Programme at a glance

(1) Course objectives and contents

The program is built around nine core modules, each of which will cover 1 week

1. The importance (and economic relevance) of public sector

2. The role of the government in an economy

3. The 'traditional' model of Public Administration

4. Public Management: definitions and characteristics

5. Regulation, Contracting and Public Ownership

6. Strategic management for public administrations

7. Financial and Performance Management

8. E-government and digital innovation in public management

9. The use of data for supporting innovation in the public sector.

Sustainable Development Goals (SDGs)

- **SDG4 - QUALITY EDUCATION** (6 h)
- **SDG10 - REDUCED INEQUALITIES** (6 h)
- **SDG11 - SUSTAINABLE CITIES AND COMMUNITIES**

Bibliography

Main textbooks

Hughes, O. E., Public management and Administration, 5th ed., Edizione: Palgrave Macmillan, 2018.

053729 Purchasing and Supply Management

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Calculus, linear algebra and some programming experience.

Learning Objectives

- Identify trends, technologies, key methodologies and stakeholder needs in Procurement and Supplier Relationships
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) coupled with participatory approaches to face problems and opportunities in a business, industrial and societal environment
- Develop new ideas and transformative solutions to deliver positive impact on business, industrial and societal scenarios evolving over time

Expected Learning Outcomes

At the end of the course students will be able to:

- Understand the strategic nature of procurement, beyond buying goods and services
- Understand the contribution of purchasing and supply to real value creation of modern organizations
- Analyse multifaceted requirements of business stakeholders to purchasing and supply managers
- Identify the mutual influence of purchasing and supply on other major functional activities, such as financial planning, information systems, product development, production planning, inventory management, forecasting, quality management, sales, human resource management
- Adopt operational tools and techniques used to carry on the purchasing activities
- Appreciate ethical, social, and legal issues faced by purchasing and supply professionals
- Provide innovative solutions to face strategic supply challenges

Topics Covered

Procurement counts nowadays up to 80% of the entire P&L (Profit and Loss account) of companies. For this reason, its impact on economic performance, financial performance, and on reputation and sustainability is huge. Therefore, to further create value, it is crucial for companies to manage sourcing and procurement activities strategically adopting a new strategic approach compared to the traditional transactional one. In particular, the course will face the following topics:

- The impact of Procurement on business performance
- Make-or-Buy strategic decisions
- Purchasing strategy
- Purchasing process

- Purchasing organization
- Portfolio Management
- Purchasing KPIs
- Vendor Rating
- Value/Cost Analysis and target costing
- Total Cost of Ownership
- Introduction to e-Procurement
- Contract and Risk Management
- Avoiding corruption and unethical behaviours
- Commodity prices and financial risk hedging
- Introduction to Innovation and Sustainability

In order to familiarize and to be able to adopt tools and methods, these topics will be deeply discussed in class and then implemented in real cases**.** Chief Procurement Officers will be also invited as guest speakers to bring real business insights. Most contents and additional advanced topics will be then further implemented in companies thanks to the Supplier Relationship Management Lab.

Bibliography

No texts suggested.

054697 Quality Data Analysis
(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

A five-credit course in Statistics is required.

Students should mainly know:

- Basics of statistical distributions (Normal, Poisson, Binomial, Chi-square, F)
- Confidence intervals and Hypothesis tests

Learning Objectives

Nowadays, an impressive amount of data can be collected in real industrial scenarios (Industry 4.0). The course presents a set of quantitative tools and methods for managing, modeling, monitoring data in industrial and business scenarios. Specific attention is given to quality data, i.e., all the key indicators of products and processes which play a relevant role in creating added value for the company. After successfully completing the course, students should be able to do the following:

- Understand the philosophy and basic concepts of quality data modelling, monitoring and improvement.
- Extract relevant information from complex, high-dimensional data
- Identify models to predict the expected pattern of quality and performance indicators
- Design and use appropriate tools to design and manage data in industrial and service scenarios.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
- Develop new ideas and solutions in business and industrial scenarios evolving over time

Expected Learning Outcomes

Lectures will provide the basic tools to understand functions and processes, using appropriate quantitative tools for data analysis. Recitations in computer labs will show how the learned tools can be effectively used to design new solutions using a scientific approach to face the problems at hand (applying knowledge and understanding). The lab project will foster an additional insight to develop new ideas and solutions in business and industrial scenarios (making judgements and learning skills).

Topics Covered

1. Quality engineering & Industry 4.0: data analysis as a basic tool for modeling, monitoring, control and improve.
2. Quality data modeling:
   - Standard assumptions and related tests;
   - Modeling patterns via linear models;
   - Modeling autocorrelated data via time series analysis;
   - Modeling survey data: Categorical and ordinal data
3. Quality monitoring of continuous variables
   - Traditional statistical process control (SPC) for the mean and the variance
   - SPC for autocorrelated data: Problems of traditional control charts for autocorrelated data;
   - Model based and model-free approaches for quality control of autocorrelated data.
4. Quality modelling and monitoring for "big" data streams: multivariate data
   - Modeling multivariate data
   - Dimensional reduction via Principal Component Analysis
   - Control chart for multivariate data - controlling the mean and the covariance
5. Toward zero-defect manufacturing: process quality and product specifications. Capability analysis. Univariate and multivariate control charts for small shifts (EWMA, CUSUM).
6. Modelling and monitoring attribute and qualitative data: control chart for defective rates and survey data
7. Quality Improvement – The role of improvement in the six-sigma roadmap. Quality improvement via empirical model building (for management engineering only- hints).

Bibliography

Main textbooks

D.C. Montgomery, Introduction to Statistical Quality Control, Editore: Wiley

Optional textbooks

L. C. Alwan, Statistical Process Analysis, Editore: Irwin Mc Graw Hill
E. del Castillo, Statistical Process Adjustment for Quality Control, Editore: Wiley

097323 Quality Management

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

For the students of engineering, the prerequisite is "basics of statistics" (in particular the use of the normal distribution table).

Learning Objectives

The course aims at offering fundamental criteria, reference frameworks and tools to manage continuous improvement of operations of manufacturing and service organizations. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance - in particular WRT products and services quality
- Identify trends, technologies and key methodologies in a specific domain (managing quality of products and services)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

Expected learning outcomes:

- Knowing the history of quality management and quality management tools
- Know and be able to apply the 5 perspectives of quality
- Know the concepts of process control and process capability and how they come to use
- Know the basic principles of Six Sigma and its masterpiece, the DMAIC methodology
- Be able to design and apply tools for improving quality of a newly developed (or improved) product: FMEA, QFD, DoE
- Be able to use tools for acceptance sampling
- Be able to design and apply control chart systems

Topics Covered

The first part of the course focuses on the concept of Quality and on its evolution, in particular during the XX century, thanks to the contribution of several companies and the works of the Quality Gurus. The second part introduces the Six Sigma methodology, which was developed in the 80's by Motorola, and elevated to a managerial philosophy by General Electric in the 90's. Considered as an evolution of Total Quality Management, Six Sigma aims at improving quality by aligning the output of a company's processes to market requirements.
In the last part of the course, students will be provided with a "tool-box", containing a number of quality management tools and techniques, which could be applied in a large number of situations, in both industrial and service companies.

Main topics

Part I – Products and services Quality Management

- Introduction to the Concept of Quality
- The History of Quality Management
- Quality Philosophies: Juran, Deming, Taguchi, Crosby, Ishikawa
- Organization of the Quality Management Department
- Quality Management Systems and the ISO 9000 set of standards

Part II – Six Sigma

- Six Sigma organization
- Six Sigma project management
- performance measurement of Six Sigma improvement projects: efficiency (costs) vs effectiveness (customer satisfaction) indicators; statistical thinking and measuring process capability

Part III – tools and techniques for quality improvement

- Voice of the Customer techniques:
  - The VoC approach in Six Sigma
  - ServQual model to measure service quality
  - Measuring Customer Satisfaction
- Tools and techniques to improve existing processes
  - DMAIC approach in Six Sigma
  - Quality Management tools: problem solving tools
  - Quality Management tools: how to correctly represent data with a graph
- Tools and techniques for new products/processes
  - Six Sigma DFSS approach
  - Quality Function Deployment technique
  - Design of Experiment and Taguchi's robust design
- Tools and techniques to improve quality of supplies
  - Acceptance sampling
  - Vendor rating

Bibliography

Main textbooks

James R. Evans and William M. Lindsay, The Management and Control of Quality, Editore: Thomson South-Western
Alessandro Brun, Matteo Casadio Strozzi and Xixi Fan, Quantitative Methods for Quality Management, Editore: Esculapio –Bologna

Recommended materials

Alessandro Brun e Matteo Casadio Strozzi, Manuale Six Sigma per le Green Belt, Editore: CreateSpace, Anno edition: 2016
Note: Testo SOLO in Italiano. Acquistabile su Amazon e disponibile GRATUITAMENTE su Kindle per gli utenti Kindle Unlimited

057108 Regulation of Digital Innovation on Payments and Finance
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Basic skills on digital innovation, information technologies, data analysis and management.

Basic principles of financial analysis, financial system, financial institutions, financial intermediaries, consumers/investors needs.

Learning Objectives

The goal of the course is to enable students to understand the ongoing debate on Fintech and how digital innovation is: i) redesigning business models of financial institutions; ii) introducing new payment instruments and financial services; iii) changing the market structure due to new strong and agile competitors. Key insights will be introduced on how policy makers are dealing with the opportunities and risks of the digitalisation of the financial sector.
At the end of the course, students will:

- Understand challenges, opportunities, functions of innovation technology in the financial sector and its effects on business, economy, environment, governance and society;
- Identify trends, technologies, key methodologies and stakeholder needs in the Fintech sector;
- Develop new ideas and transformative solutions to deliver positive impact on business, industrial and societal scenarios evolving over time, designing and presenting related projects.

Expected Learning Outcomes

Expected learning outcomes:

- Lectures and exercise sessions will allow students to:
- Know the main Fintech topics
- understand the role and the challenges of regulation dealing with Fintech
- Know the recent technological developments and potential scenarios in the Fintech sector
- Understand the related regulatory and supervisory requirements

Project sessions will allow student to:

- Write a project plan document
- Identify the goals and tools
- Summarize and present the project

At the end of the course, students will be able to:

- Assess the impact of innovation on the finance sector
- Analyse and understand opportunities and risks of new emerging Innovation in the financial sector
- Design projects to achieve the needs emerging in the financial sectors leveraging on the innovation technology

- Comply to the related regulatory and supervisory frameworks

Topics Covered

- Overview of the current Fintech market and regulatory framework at the international and European level
- Big data and ML applications to financial services, with a focus on AI-powered credit scoring systems
- Risks and opportunities of decentralized systems in payments and finance
- Cloud computing, outsourcing and risk management
- Open banking and open finance
- Fintech credit and platformization
- Innovation facilitators: new policy instruments to approach Fintech and the current framework at the European and Italian level
- Retail payments
- Stablecoins, Central Bank Digital Currencies and the future of payments
- Electronical identity (eID) in finance
- Digital platforms and finance
- Privacy and data: risks and opportunities for financial institutions between GDPR and PSD2

Sustainable Development Goals (SDGs)

This course contributes to achieve the following Sustainable Development Goals:

- **SDG9 - INDUSTRY, INNOVATION AND INFRASTRUCTURE**

Bibliography

No texts suggested.

057048 Service Design and Innovation – Smart Service
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

The aim of the course is to convey the theoretical foundations of service design through theoretical lessons and case studies, also focusing on how this relates to innovation processes. The course provides students with knowledge of key concepts and theories related to service design and innovation, focusing on their relationship with the digital, technological, social, and environmental transformations underway.

Expected Learning Outcomes

Students:

- Know and understand the main service design theories and related approaches and know how to discuss them
- Can conduct theoretical research, working autonomously and in group, to apply it to the analysis of case studies and issues and to develop personal argumentations
- Can relate the insights and models coming from service design theory to the needs and developments of service design practice

Topics Covered

Service Design & Innovation is a theoretical course that guides students to study the theories and practices around service design and service innovation. Services are now fully recognized for their fundamental role in the growth of the economy and employment of most developed countries; they are also valued for their transformational role in society being deeply embedded in how we live, work, produce and create social relationships. They are also undergoing deep transformations due to the digital transition and are heavily influenced by the green imperative.

Service Design as a discipline applies creative and human-centered design processes, methods and tools aimed at improving and innovating services. These range from services in the private, public or third sectors, and are relevant for all types of organizations.

To develop capabilities aimed at innovating services, several areas of knowledge need to be mastered including experience and interaction design, organizational and behavioural change, system design and system thinking. It does require multidisciplinary contributions where Design can play and is increasingly playing a key role in bringing people at the centre of any innovation process.

The course will cover a range of topics, from the basics of Service Design to its contemporary evolutions. This will include Service systems, Service Models, Service Innovation, Service Logic, Service Evaluation, Policy Making, New Technologies, Design Capabilities.

Sustainable Development Goals (SDGs)

This course contributes to achieve the following Sustainable Development Goals:

- **SDG9 - INDUSTRY, INNOVATION AND INFRASTRUCTURE**
- **SDG11 - SUSTAINABLE CITIES AND COMMUNITIES**
- **SDG12 - RESPONSIBLE CONSUMPTION AND PRODUCTION**

SDG9 - lectures on: Service Economy and Service Innovation, Digital opportunities for new services, new business models for digital services - Total number of teaching hours: 12

SDG11 - lectures on: Digital services for public interest and public value - Total number of teaching hours: 4

SDG12 - lectures on: Service systems and systems thinking, complexity thinking in smart services - Total number of teaching hours: 8

Bibliography

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Boyle, D. and Harris, M. (2009). The challenge of co-production. How equal partnerships between professionals and the public are crucial to improving public services, Nesta, London.

Csikszentimihalyi, M. (1990). Flow: The Psychology of Optimal Experience. New York: Harper.

Czepiel, J., Solomon M. e Suprenant C. (ed.) (1985), The Service Encounter. Managing Employee/Customer Interaction in Service Business, Lexington Books, Lexington (MA).

Forlizzi J. and Ford S. (2000), The building blocks of experience: an early framework for interaction designers, Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques, p.419-423, August 17-19, New York City, New York, United States.

Grönroos, C. (2011). Value co-creation in service-logic: A critical analysis. Marketing Theory, 11(3), 279.

Junginger, S. and Sangiorgi, D. (2009), Service Design and Organisational Change. Bridging the gap between rigour and relevance, IASDR09 conference, 19-22 October, Seoul.

Kimbell, L. (2011). Designing for Service as One Way of Designing Services. *International Journal of Design, 5(2).*

Meroni A., Sangiorgi D. (2011), Design for Services, Gower Publishing Ltd.

Parker, S., and Parker S. (2007). Unlocking Innovation: Why citizens hold the key to public service reform. Demos: London.

Parker, S. and J. Hoepy, (2006). The Journey to the Interface. How public service design can connect users to reform. London: Demos.

Sangiorgi, D. and Prendiville, A. (2017). Designing for Service. Key issues and New Directions, Bloomsbury Publishing.

Sanders, B.-N., Elizabeth, & Stappers, P. J. (2008). Co-creation and the new landscapes of design. CoDesign, 4(1), 5-18.

Solomon, M., Suprenant C., Czepiel J. and Gutman E. (1985), A Role theory Perspective on Dyadic Interactions: The Service Encounter. *Journal of Marketing; Winter85, Vol. 49 Issue 1, p.99-111.*

Vargo, S., & Lusch, R. (2008). Service-dominant logic: continuing the evolution. Journal of Academic Marketing Science, 36(1), 1-10.

056985 Smart Maintenance Management
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

It is recommended that students have skills and competences in design and management of production systems.

Learning Objectives

The goal of the SMM course (first half of the semester) is to introduce the student to a modern maintenance practice and advanced solutions for increased productivity, today vital for companies in every sector. The maintenance is indeed experiencing a radical evolution, moving towards an advanced management of the physical assets in order to guarantee the reliability, availability, quality, safety and costs in the operations of engineered systems. The course will particularly address this evolution in the context of industrial plants in discrete manufacturing and process industry. The SMM course fits into the overall program curriculum, pursuing some of the defined general learning goals and, in particular, contributing to the development of the following capabilities:

- Understand context, functions, processes, resources and decisions of industrial maintenance, and their impacts in terms of asset-related performances, costs and risks;
- Identify trends, technologies and methodologies to support decision-making to manage maintenance based on data and evidences from field, while orienting to the strategic requirements due to operations of the industrial plants and the business needs;
- Design solutions for industrial maintenance built on the smart application of an engineering approach to face problems and opportunities in a business and industrial environment.

Expected Learning Outcomes

By the end of the ALCM course, students will learn contents and practices according to what is defined in the leaning objectives. The learning is correspondingly organized considering the course delivery in SMM and IAM topics.

Smart Maintenance Management (SMM)

The expected learning outcomes of the SMM course, achievable through lectures and exercise/case study sessions, consist of knowledge and understanding of the criteria and methods to support decisions for industrial maintenance, and of the practical abilities to analyse performances, costs and risks to support a smart maintenance decision-making. In particular, the course will allow students to achieve knowledge and understanding in order to:

- Name and define, with precise terminology, context, functions, processes, resources and decisions within the scope of industrial maintenance management;
- Recognize and discuss the role of industrial maintenance management for what concerns its impacts in terms of reliability, availability, quality, safety and costs;
- Describe and explain the main performances, costs and risks impacted by a smart management approach in industrial maintenance;

- Describe and explain the main criteria, modeling techniques / methods, and methodologies to support a smart management approach in industrial maintenance;
- Identify, describe and analyse the use of key enabling technologies for a smart decision-making support based on data analytics.

The course will also allow students to be able to practically apply the acquired knowledge and understanding in specific problem settings, proposed in the exercise/case study sessions and requiring abilities of analysis and synthesis abilities leading to:

- Distinguish different contexts and requirements identified in specific problem settings, eventually being able to understand problems and opportunities in a given business and industrial environment and to formulate the goals in terms of performances, costs and risks addressed by the physical assets;
- Analyse the data sets provided within specific problem settings, to assess and/or to predict the related performances, costs as well as the risks due to uncertainties in attainment of the goals;
- Design solutions for a smart management approach in industrial maintenance, considering contexts and requirements due to specific problem settings, targeted performances and costs, and the requirements for risk mitigation.

Hence, through exercise/case study sessions, students will acquire the skills to formulate a judgment, meaning to distinguish specific problem settings, analyse the data sets provided with these settings, and design solutions for cost-effective decisions in maintenance management.

Topics Covered

The goal of the course is to introduce the student to a modern maintenance practice and advanced solutions for increased productivity, today vital for companies in every sector. In particular, the radical evolution towards an advanced management of the physical assets can completely redefine the role of maintenance, which can become the key function of a more complex and integrated management concept along the lifecycle management of the assets. The role of maintenance in the asset lifecycle management is then considered as decisive factor for: reducing costs; optimizing the service provided by the assets; guaranteeing safety, quality, reliability and availability; maximizing the value obtained from the assets use, finally contributing to the company competitiveness. This evolution takes advantage of the development of new maintenance concepts capable to exploit: i) advanced ICT and plant automation; ii) new diagnostic and prognostic technologies to assess and predict the health state of the assets; iii) new management concepts, whose foundations are a data-driven decision-making and the role of human capital resource, supported by augmented intelligence available from an advanced technology support.

Considering the overall developments and expected trends, the following topics are presented during the lectures and practically tested by means exercise/case study sessions:

- Role of maintenance management within the lifecycle management of physical assets
- Basics of reliability, maintainability, availability and maintenance costs
- Maintenance policies and cost optimization
- Prognostics and Health Management for Condition Based and Predictive Maintenance programs
- Data analytics for Prognostics and Health Management of physical assets
- Methodologies, methods, techniques for Reliability and Maintenance Engineering, including Reliability Centered Maintenance and Total Productive Maintenance
- Smart/Intelligent Maintenance practice based on Key Enabling Technologies in Industry 4.0

- Maintenance personnel and the role of human capital resource with Knowledge, Skills and other abilities

Bibliography

Main textbooks

Lecture slides and tutorials https://beep.metid.polimi.it

Optional textbooks

A. Crespo Marquez, The Maintenance Management Framework. Models and Methods for Complex Systems Maintenance, Editore: Springer, Anno edition: 2007

Andrew K.S. Jardine, Albert H.C. Tsang, Maintenance, Replacement, and Reliability. Theory and Applications, Editore: CRC Press, Anno edition: 2013

J. Lee, Industrial AI. Applications with Sustainable Performance., Editore: Springer, Anno edition: 2020

L. Furlanetto, M. Garetti, M. Macchi, Principi Generali di Gestione della Manutenzione, Editore: FrancoAngeli, Milano, Anno edition: 2006

L. Furlanetto, M. Garetti, M. Macchi, Ingegneria della manutenzione, Editore: FrancoAngeli, Milano, Anno edition: 2007

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A. Crespo Márquez, M. Macchi, A. K. Parlikad, Value Based and Intelligent Asset Management: Mastering the Asset Management Transformation in Industrial Plants and Infrastructures, Editore: Springer, Anno edition: 2019

J. E. Amadi-Echendu, K. Brown, R. Willett, and J. Mathew, eds., Definitions, concepts and scope of engineering asset management, Editore: Springer, Anno edition: 2010

J.D. Campbell, A.K.S. Jardine, J. McGlynn, Asset management excellence: optimizing equipment life-cycle decisions, Editore: CRC Press, Anno edition: 2016

N.A.J. Hastings, Physical Asset Management, Editore: Springer, Anno edition: 2010

056948 Smart Manufacturing Lab
(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Industrial engineering methods and tools addressed in the previous courses.

An assessment exercise for soft-skills and group-work attitudes is suggested (check the offer provided by the Career Service).

Learning Objectives

The aim of the course is to provide the students with an opportunity to face real problems in real manufacturing environments through the application of smart manufacturing methods to support the engineering and management of high-value-added products, the continuous innovation of products and processes, the sustainability of products and production systems along their lifecycle.

The smart manufacturing approaches exploited in the course will focus on complex manufacturing challenges addressing products, production process, systems and their continuous evolution, entailing a wider engineering perspective.

The integrated Smart Manufacturing Lab (5+5 CFU) will pursue this perspective to tackle manufacturing problems like the design and reconfiguration of manufacturing systems, zero-waste and sustainable solutions for manufacturing, integrated product-process approaches for personalization, advanced planning and scheduling in complex and uncertain environments, prognostics and health management of manufactured assets, reliability and availability improvement in manufacturing systems.

The students will have the opportunity to take advantage of smart manufacturing methods and tools and experimental experience to solve real industrial problems through the "action-based learning" approach used in the "learning factory". Moreover, the students will enhance their capability to interact in a professional environment in a responsible and constructive way, working in a group, planning and coordinating roles and activities within the group, and interacting with a company providing the context where the real case is set and solved.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment;
- Develop new ideas and solutions in business and industrial scenarios evolving over time;
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members.

Expected Learning Outcomes

The main expected learning outcomes of the course, achievable through a mix of activities aimed at implementing the "action-based learning" (Seminars/Lectures, Lab experience, Industrial Internship, Real data modeling and analysis), consist of knowledge and comprehension of the smart manufacturing methods and the practical abilities to use them in the context of real industrial environments. In particular, the course will allow students to achieve knowledge and comprehension in order to:

1. Analyse and model a real problem in a real manufacturing environment, understanding the relevant elements and influencing factors, defining proper modelling hypothesis, collecting information and data;
2. Select and apply smart manufacturing methods to real industrial cases, coping with incomplete and/or unreliable information and data;
3. Work and cooperate in a team and interact with a company;
4. Plan and manage their work grounding on the intermediate results and the evolution of the context;
5. Explain, communicate and motivate the work done;

Topics Covered

Starting from a real industrial case, a set of engineering problems will be defined, addressing the range of typical problems a manufacturing company has to face in a multidisciplinary way by a group of students spending about 5 weeks in a company, with the aim ~~at of e~~xploiting the tools and methods learned to analyse, formalize and provide a solution to it.

The following activities will be carried out:

- Industrial Internship: all the students will be given the opportunity to spend a period of about 110 hours in the company proposing the manufacturing problem under study. The period will be organized as an internship through the Career Service.
- Seminars/Lectures: seminars/lectures will be organized to deepen all the technological and management aspects connected to the problem under study.
- Lab experience: specific problems will be addressed by the students by directly using labs and facilities at the Department of Mechanical Engineering, Department of Industrial Engineering as well as other facilities working in close relation with Politecnico di Milano.
- Real data modelling and analysis: data collected in real industrial contexts will be provided and used to design and/or validate the solutions provided.

Bibliography

Main textbooks

Lecture slides and tutorials https://beep.metid.polimi.it

057614 Social Entrepreneurship
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Fundamentals and basic concepts of management.

Learning Objectives

Over the last decade, a new type of entrepreneurial approach has gained traction around the globe, inspired by the search for novel, sustainable solutions to complex social challenges. Adopters of this approach, labelled as social entrepreneurs, develop and deploy innovative solutions to improve living conditions in their communities and address the needs of the society, simultaneously combining the pursuit of purpose and profit. In other words, they attempt to solve a societal problem through innovation in a financially sustainable manner. This paradigm represents a new generation of businesses forged by the need to respond to major social and environmental challenges.

Students in the course will learn how entrepreneurs can identify and exploit opportunities to develop solutions aimed at solving social and environmental problems and the peculiar challenges of managing an enterprise that realizes a dual process of value creation, both social and economic. The course will offer students the opportunity to practice their critical thinking applied to real-world situations. The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand the concept of social entrepreneurship, how an entrepreneurial process for social change unfolds and the peculiar challenges of dual, social and economic, mission management;
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to transform a system-changing idea into a long-term sustainable entrepreneurial initiative;
- Interpret real-world situations of managing socially-oriented hybrid organizations that strive to create systemic change in society;
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members.

Expected Learning Outcomes

At the end of the course, the students will be able to:

- Understand the process of opportunity identification and opportunity exploitation applied to the search of solutions for social and environmental problems;
- Analyse the possible tensions peculiar to the management of social venture;
- Apply theory and empirical evidence to envision and realize solutions to the potentially destructive and constructive trade-off situation experience in managing social enterprises.
- Design the different elements of a hybrid socially-oriented business model;

- Analyse funding needs and sources for different types of social enterprises;
- Assessing the readiness of a social entrepreneurial project to be scaled and identify possible challenges;
- Select the scaling strategy given the specific characteristics of the social venture;
- Describe the main concepts and frameworks to measure the firm's performance in terms of the social and environmental impact generated;
- Understand team working dynamics, develop leadership, negotiation skills, and conflict management ability (case study teamwork assignment);
- Develop communication skills and communicate the key concepts in a public context as well as in a written document (in-class case discussion and case study teamwork assignment);
- Be aware of how they might apply social entrepreneurial skills in their future careers' opportunities.

Topics Covered

The course includes:

- <u>Lecture sessions</u>: they aim at outlining and discussing conceptual frameworks, tools and empirical evidence.
- <u>In-class case study discussions</u>: they aim at making students apply the insights from theory and empirics to understand the challenges of managing a venture with a hybrid social and economic purpose. Students have to read case study materials prior to the class sessions.
- <u>Testimonials</u>: guest speakers will be invited to share their practical experiences with the class.

Course Detailed Program:

- <u>SETTING THE BOUNDARIES</u>
  - The current trends and societal challenges and the quest for a new capitalism
  - The fundamentals of a purpose-driven economy

- <u>DEFINING SOCIAL ENTREPRENEURSHIP</u>
  - Combining profit and purpose: hybridity and social impact
  - A definition and taxonomy of socially oriented hybrid organizations
  - The legal framework for impact-oriented hybrid organizations

- <u>DEVELOPING A BUSINESS STRATEGY FOR SOCIAL CHANGE</u>
  - Designing a socially-oriented business model
  - Reinterpreting the notion of firm growth: scaling social impact
  - Planning a sustainable scaling path for social enterprises
  - Funding social enterprises: challenges, opportunities and novel approaches.
  - Measuring and managing social and environmental impact in social enterprises
  - Technology, innovation and management of Social-Tech Ventures
  - Becoming a Social Entrepreneur: Unfolding the process

Bibliography

Main textbooks

Slides provided by the Professor; Readings provided during the course; Text of case studies.

057043 Strategic Innovation
(5 ECTS credits)

The course is offered in the:

Fall Semester (Feb – May)

Prerequisites

Students will need to have a detailed knowledge of the classical strategy making process and of the key tools used in this process (e.g., PESTEL, Porter 5 Forces Model, Value Chain analysis, SWOT analysis, Business Model Canvas).

Learning Objectives

The main Learning Goals (LGs) of the course are:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance. The focus will be in particular on understanding processes of strategic innovation in established organizations, their nature, underlying mechanisms and impact on sustained competitive advantage.
- Identify future trends, technologies and key methodologies in a specific domain. The focus will be in particular on identifying the methodologies that allow established organizations to lead processes of strategic innovation
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment. In particular, the focus will be on designing solutions to strategic innovation problems.

Expected Learning Outcomes

- Classify different types of strategic innovations
- Interpret how strategic innovation impacts sustained competitive advantage
- Analyse the factors that affect the ability of an established organization to pursue processes of strategic innovation
- Illustrate the process that established organizations should follow to successfully pursue strategic innovation
- Classify the tools and approaches that should be used in this process to ensure success in strategic innovation
- Design a process of strategic innovation in established organizations by using the strategic compass model
- Interpret the role of purpose in strategic innovation processes

Topics Covered

Strategic innovation can be defined as the creation of growth strategies, new product categories, services or business models that change the game and generate significant new value for consumers, customers and the corporation. Confronted with extraordinary and unpredictable shifts in the competitive landscape, fast-changing customer needs, and technological disruptions, companies need to develop a capability to re-think their existing sources of value creation and capture, challenge the status-quo, embark in deep transformation, and this much more frequently than what happened only a few years ago. Any manager and business professional needs today to understand the challenges that strategic innovation poses, the approaches that are needed to trigger and implement it, and the capabilities that leading strategic innovation requires. This course aims to provide an answer to these needs by equipping students with the concepts, tools and skills that will help them (i) understand the importance of strategic innovation for today's sustained competitive advantage, (ii) create conditions in which strategic innovation can flourish (iii) trigger and realize a process of strategic innovation, across all the levels of change that it entails. In particular, the course will explain the importance of purpose as a key force to shape strategic innovation processes, to generate energy and commitment toward ambitious results, and to deliver positive impact on society on top of creating higher projects and shareholder's value.

The course is based on an experience-based, peer-to-peer learning approach, whereby students will be asked to frequently work in teams to critically reflect on the key concepts taught during the program, and to present the output of their work to the entire class, to share experiences and points of view. Moreover, this course starts from the assumption that strategic innovation is such a complex and multifaceted discipline that it requires exposure to practical experiences to be understood and learnt. Therefore, the course will rely on a significant number of guest lectures and speeches from professionals, top managers, and practitioners, which will provide a deep-dive and hands-on view of the Topics Covered by the program. As a result of this, each class is dedicated to the presentation and discussion of the teamwork that the students will be preparing during the program, to the illustration of the key concepts and themes of the week, and to guest lectures illustrating these key concepts in practice. In particular, this course will be taught by Prof. Federico Frattini together with Dr. Arrigo Berni, Partner at The Mind At Work Italy and former CEO of Moleskine (2006-2016), who will offer a thorough illustration and discussion of the history of strategic innovation Moleskine has gone through these ten years, to provide a real and live illustration of the topics covered in the course. The instructor team will include also Dott. Luca Manelli, PhD Candidate at the School of Management of Politecnico di Milano, and an expert in purpose-led strategies, identity, and strategic transformation processes.

To succeed in Strategic Innovation, any manager and business leader will have to face two distinct, although interrelated challenges. On the one side, he/she has to establish in the organization some conditions, practices, processes that allow it to be fertile ground where strategic innovation can flourish. On the other side, once an idea of strategic innovation is identified, he/she has to be able to trigger and implement this process of strategic change and transformation. The structure of the course reflects these two challenges.

Part I – Creating the Conditions for Strategic Innovation

Week 1: What is strategic innovation and why it is important today

Week 2: Overcoming inertia to strategic innovation

Week 3: Searching opportunities for strategic innovating

Week 4: Learning for strategic innovation

Week 5: Venturing for strategic innovation

Part II – Realizing Strategic Innovation

Week 6 and 7: Workshop on Leading Strategic Innovation with Purpose with led by Federico Frattini & Arrigo Berni

Week 8: Goals

Week 9: Culture

Week 10: Identity & Brand

Week 11: Organization

Week 12: Knowledge & Competences

Conceptually, between Part I and II managers and decision-makers engaged in Strategic Innovation will have to choose which type/form of Strategic Innovation and course of action to pursue. To do so, they can use a set of tools that students of the Strategic Innovation course will have already deepened in their Management Engineering curriculum, such as PESTEL, Porter 5 Forces Model, Value Chain analysis, SWOT analysis, Blue Ocean Strategy, Disruptive Innovation Theory, and many others. A summary of these tools is available, e.g., here: https://www.strategy-in-3d.com/

Bibliography

Recommended materials

Vijay Govindarajan and Chris Timble, Ten Rules for Strategic Innovators: From Idea to Execution, Editore: Harvard Business Review Press, ISBN: 9781591397588

052321 Strategic Planning in Real Practice ()

(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Strategy MOOC on the POK platform, this course introduces the key theories, concepts, models and approaches related to Strategy at a Corporate, Business and Functional/Operational level. (Available at: https://www.pok.polimi.it/courses/course-v1:Polimi+STR101+2017_M9/about)

Learning Objectives

Leonardo S.p.A., formerly Finmeccanica, is an Italian global high-tech company and one of the key players in aerospace, defence and security sectors. From 2014, the beginning of the mandate of the CEO Mauro Moretti, the company started a restructuring process that led to a re-launch of the brand after years of unsatisfying performances. The intervention lines can be summarized into three main points: focus on core businesses, disposal of non-core activities and shift form a holding to a "one company". As part of the restructuring process, Finmeccanica finally changed its name to Leonardo S.p.A. on 1 January 2017.

The objective of the course is to understand the key aspects of the turnaround thanks to the witness of who led the change. Ing. Moretti will share his experience within the company, discuss the reasons behind the actions put in place and the resistance encountered. Particular attention will be paid to the role of the stakeholders and to the macro-economic and geo-political scenario that strongly influence the decisions in the target sector.

An important part of the course is dedicated to laboratories in which students - organised in groups - will develop the topics and carry out challenges proposed during lessons. To foster interaction and sharing, findings from group works will be discussed in classroom.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

At the end of the course, the student will be able to:

- Understand the complexity of managing a multi-national firm, the key aspects of an industrial plan and of its implementation.
- Understand the characteristics of the aeronautics, defence and security sector.

- Understand how to design and implement solutions to face problems in a business and industrial environment

Topics Covered

The focus of the course is the analysis of the real case of Finmeccanica's turnaround of the latest years. Ing. Moretti, former CEO of the firm, will share his experience and propose topics and challenges that will be developed by students in groups. The results of each group session will be discussed in class with the advocacy of Ing. Moretti and Ing. Robbiani in order to foster interaction.

Main Topics

The course is based on three main topics:

- Analysis of an industrial corporation:
    - The result of Finmeccanica-Leonardo before and after the turnaround by analysing the financial performances, the competitive advantage and the macro-economic and geo-political scenario.
    - The business portfolio and the individuation of the core businesses
- Planning action & business sectors:
    - Understand in detail what are the actions implemented by Ing. Moretti to revitalize the company, synthetized in pursuit efficiency in the core businesses, disposal of non-strategic businesses and creation of "one company".
    - Focus on two important businesses of Finmeccanica-Leonardo: the helicopters and the space sector. Discuss how those sectors will evolve in the future mentioning the so called "space economy"
- Managing the change:
    - Complexity of the implementation of an industrial plan.
    - Understand how a real change is possible only by motivating the human capital, key resource of a firm.
    - Discuss how the international stakeholder and the geo-political scenario influence the aeronautics, defence and security sector.

Groups

For the practical assignment to be fulfilled during the course the students are required to work in groups. The size of the groups and the way students will team up will be defined during the course.

Bibliography

Main textbooks

Slides, tools, business cases and videos https://beep.metid.polimi.it/

052795 Strategy & Marketing

(10 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Students who did not obtain a Bachelor Degree in Management Engineering at Politecnico di Milano are strongly recommended to acquire the basic notions of strategy that will be delivered through the MOOC "Strategy" before the beginning of the course.

Learning Objectives

The goals of this course are to enable students to understand and interpret the current competitive and marketing environment and their evolution; and to evaluate their impact on business performance. This course will allow students to understand a Company's value generation mechanisms and its strategic and marketing processes in the light of the ongoing digital transformation, and how to translate these processes into managerial activities.

The course will present the major concepts, theories, methodologies and tools to support the strategic and marketing decision making process. It will also introduce the strategic methodologies and tools to launch a new business, either within an existing company or through a start-up company. The discussion of business cases and real-world examples will encourage students to examine and get familiar with the abovementioned theories and models as well as their practical implications.

Expected Learning Outcomes

- Identify and apply the appropriate tools to analyse the competitive environment and the Company strategy
- Discern and select the appropriate strategic approaches and marketing practices for different company typologies
- Identify the appropriate strategic methodologies and tools to launch a new business
- Identify and apply the appropriate tools to analyse the competitive environment and the Company strategy
- Discern and select the appropriate strategic approaches and marketing practices for different company typologies
- Identify the appropriate strategic methodologies and tools to launch a new business

Topics Covered

Strategy
Concepts, theories and models supporting the strategic decision-making process. The main topics are: strategy, strategic decision and strategic analysis; business unit strategy, value chain, competitive advantage, competitive forces, SWOT analysis; corporate portfolio strategy, portfolio matrices; strategic innovation and creativity (e.g. resource-based view and blue ocean strategy), business model design and innovation, digital disruption.

Marketing

Concepts, theories and models supporting the marketing decision making process. The main topics are: customer behaviour, segmentation and targeting, value proposition and positioning, branding, marketing mix & customer experience.

Entrepreneurial Strategy

Models, methodologies and tools enabling the launch of a new business. The main topics are: business planning, the lean start-up approaches, the start-up financing, resource gathering and allocation.

The lectures will be supplemented by the active class discussion of business cases and by real-world examples.

Bibliography

Main textbooks

R. Grant, Contemporary Strategy, Editore: John Wiley & Sons
P. Kotler, K. Keller, Marketing Management, Editore: Prentice Hall

052816 Supplier Relationship Management LAB
(10 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Basic competences of Supply Chain Management are necessary, with specific focus on supply chain definitions, supply chain strategy, supply chain configuration, main make or buy choices. These topics are covered in the course of Supply Chain Management.

Learning Objectives

The aim of this Laboratory is to expose students to the most adopted tools by companies in managing their relationships with suppliers. In particular, participants will study and apply tools to analyse the supply market, scout and qualify new suppliers, negotiation practices and techniques, spending analysis and classification methodologies, and finally, vendor rating tools and techniques. All these tools are discussed with a panel of Chief Procurement Officers during the semester and are applied to different real cases in small working groups.

This laboratory will focus on managing relationships with suppliers, along the whole relationship lifecycle: market analysis, suppliers scouting and qualification, negotiation, spending analysis, vendor rating. It will enhance students' capabilities to:

- Negotiate with suppliers and manage the relationships;
- Evaluate their capabilities and performance;
- Analyse and rationalize the overall spending.

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment
- Develop new ideas and solutions in business and industrial scenarios evolving over time
- Interact in a professional, responsible, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

At the end of the course, the student has the following skills:

- Is able to read a real business problem and identify appropriate and valuable solutions, through a quantitative assessment of the options and a critical review of the results
- Is able to apply different procurement models in specific business contexts, to improve the performance of the purchasing department and to face new challenges of the business
- Is able to understand a business scenario and develop solutions to improve the processes and competences of the procurement department in an innovative way,

through the application of structured models and with an assessment of the implications in the short and long term
- Is able to present solutions and ideas in a professional and constructive way, fostering the value of the teamwork, and using a language adequate to both managers and fellow students

Topics Covered

Market Analysis: assessment of the current supply market and evaluation of potential different supply markets, including market structure and fragmentation, outsourcing strategies, suppliers cost structure, prices volatility, Supply Chain Finance. Market analysis will also allow to study and apply some key risk management policies.

Suppliers scouting and qualification: once the supply market characteristics are known, buyers must scout for potential suppliers. That includes scouting and qualification procedures, technical assessments, financial evaluation, overall sustainability assessment.

Negotiation: The negotiation process is a key element of the relationship with suppliers. Students will practice negotiation process and techniques, win-lose vs win-win negotiations, preparing and acting the negotiation, electronic negotiations.

Spending analysis: in order to support the negotiation process and to manage proactively the relationship with suppliers, buyers apply tools and methodologies to analyse the spending, adopt quantitative and qualitative portfolio matrixes, and design proper business cases and action plans for improvement.

Vendor rating: in order to continuously drive supplier performance, it is important to measure and assess the supplier base through specific Key Performance Indicators, stimulate supplier's development, and rationalize the supply base.

Course organization

The course is practice-oriented, classes are managed either through case studies and simulations or through a direct interaction with purchasing managers.

Students will be divided in groups of 4-5 people since the beginning.

The group will run an in-depth business case, to apply different models in a specific context.

Then, each group will be assigned to a specific problem/challenge within a company and will work on this problem along the semester. In order to face the challenge, students will apply a set of different tools and methodologies applied by companies in that specific field.

Groupwork might be performed in two different ways, according to each specific case:
- Synchronous: groups will work on group activities in class all together.
- Asynchronous: groups will work on their own on the case.

Moreover, 3 Chief Procurement Officers will be involved during the course in order to present and discuss with students their professional daily life.

Bibliography

No texts suggested

056989 Supply Chain Innovation
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

Some fundamentals of supply chain management and strategy. Nevertheless, the course will provide a recap of the essential/required basics.

Learning Objectives

The Supply Chain Innovation course provides students with a framework of relevant innovations regarding the supply chain. In particular, it explains how supply chains can be a source of innovation to achieve excellent performance. It also illustrates how innovations, not necessarily created for a supply chain context, can be leveraged to integrate the supply chain. Whereas the course provides different classifications and typologies of innovations, it especially capitalizes on the distinction between technological and value innovation. Technological innovation (e.g., digital technologies) is created by the process of research and development, while value innovation is about offering new value propositions and business models along the supply chain. Thus:

- Students will learn about the sources of technological and value innovations in the supply chain.
- They will also be able to understand the benefits, strengths, as well as challenges and weaknesses of existing innovations, so that they can better leverage them in a real context.
- Students will learn various tools that enable them to evaluate the suitability of technological and value innovations for the supply chain as well as their performance (e.g., in terms of operational impacts, sustainability or resilience)
- As such, students will be able to design innovative supply chains and build new business models that have special requirements on the supply chain structure and flows inside.

Expected Learning Outcomes

Upon completion of this course, the students are expected to demonstrate ability:

- To understand the functioning and potential of current and promising (future) technological and value innovations in supply chains, while being able of evaluating their strengths and limitations.
- To select the right combination innovations for specific supply chain problems with the objective of improving overall supply chain performance.
- To successfully interact with professionals from different disciplines and backgrounds such as research and development, supply chain management and logistics, business development, marketing, and ICT, by setting up adequate procedures for the introduction of innovations into the supply chain (e.g. suitable change management tools).
- To map supply chains and identify potentials for improvement through adequate technological and value innovations.
- To conceptually develop new value innovations along the supply chain and design adequate implementation plans to achieve supply chain transformation.

- To leverage technological and value innovation along the supply chain to achieve supply chain resilience and sustainability.

Topics Covered

- Overview of supply chain management and supply chain processes
- Overview on innovation and innovation processes
- Basics of technological and value innovation
- Supply chains: a driver for Technological and value innovation
- Technological and value innovation as driver for innovative supply chains
- Supply chain transformation through (digital) innovation

Bibliography

Recommended materials

Lyon, Ken; Manners-Bell, Johon (2019): The Logistics and Supply Chain Innovation Handbook, London et al.: KoganPage (2019).
Ross, David Frederick (2011): Introduction to Supply Chain Management Technologies, Boca Raton et al.: CRC Press (2011).
Sanders, Nada R. (2016): How to Use Big Data to Drive Your Supply Chain, California Management Review, Vol. 58, No. 3, pp. 26-48.
Van Hoek, Remko; Fugate, Brian; Davletshin, Marat; Waller, Matthew A. (2020): Integrating Blockchain into Supply Chain Management, London et al.: KoganPage 2020.

056999 Supply Chain Management

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

Supply chain management (SCM) is an important function in private and public organizations, both in the manufacturing and the service sector. SCM has strong roots in the established business functions such as logistics, operations management, and purchasing, but it constitutes a holistic concept that not only includes internal functions, but also external business partners such as upstream suppliers and downstream distributors and customers. A supply chain consists of several key processes: sourcing, manufacturing, delivering, and returning.

The course is designed to provide students with a comprehensive framework, as wide-ranging and in-depth as possible, on issues related to the management of supply chains and a high-level vision of the challenges, trends and emerging issues. In addition, the course introduces a set of tools and approaches that support professionals in better interpreting and managing supply chain challenges.

Thus, the course contributes to providing students with the ability to:

- Analyse supply chain configurations and performance
- Design different supply chain management strategies
- Understand and apply relevant supply chain practices
- Assess the relevance and challenges of sustainable supply chain management
- Identify and analyse trends, technologies and their impact on supply chain management
- Design solutions by leveraging a scientific and engineering approach that is based on analysis, learning, reasoning, and modelling capability deriving from a solid and rigorous multidisciplinary background to face SCM challenges
- Interact in a professional, responsible, effective and constructive way in a team working environment

Expected Learning Outcomes

Having completed this course, the students are expected to show an elevated ability in:

- Identifying trends and analysing their impact on supply chain decisions
- Designing SCM strategies
- Making relevant decisions in SCM by leveraging important tools and frameworks
- Interacting with colleagues and professionals from different disciplinary areas in complex problem settings and enabling them to highlight SCM issues and explaining the impact of external decisions on SC performance

Topics Covered

The Supply Chain Management Course consists of the following contents:

- Supply Chain Introduction
- Supply Chain Strategies / Supply Chain Integration
- The Value of Information for Supply Chain Management
- Basics of Inventory Models for Supply Chains
- Product Design and Supply Chain Management
- Supply Chain Metrics for Performance Measurement
- Supply Chains, Information Technology, and Business Models
- Global Issues in Supply Chain Management
- Supply Chain Management and Sustainability
- Supply Chains and Risk Management

Bibliography

Recommended materials

Simchi-Levi, David; Kaminsky, Philip; Simchi-Levi, Edith (2003): Managing the Supply Chain - The Definitive Guide for the Business Professional, New York et al.: McGraw-Hill 2003.

Chopra, Sunil; Meindl, Peter (2016): Supply Chain Management: Strategy, Planning, and Operation, 6th Edition, Essex: Pearson 2016.

Simchi-Levi, David (2010): Operations Rules - Delivering Customer Value through Flexible Operations, Cambridge/London: MIT Press 2010.

Sheffi, Yossi (2015): The Power of Resilience - How the Best Companies Manage the Unexpected, Cambridge/London: MIT Press 2015.

Sheffi, Yossi (2018): Balancing Green - When to Embrace Sustainability in a Business (and when not to), Cambridge/London: MIT Press.

057034 Sustainable and Social Innovation Lab

(10 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Knowledge about the main theories of firms' strategy and business development.

Learning Objectives

This laboratory is designed as a training arena based on learning by doing.

The laboratory aims to provide students with concepts and instruments for new sustainability and social challenges. Students will explore and become familiar with the business models and corporate strategies through new managerial approaches, new forms of collaboration, innovative technology, and product and process innovation.

In particular, the students will study and apply tools to analyse and manage corporate sustainability strategies, social innovation processes, sustainability and impact integration in new hybrid organizations, new social business models, innovative scaling strategies, as well as partnerships among different actors of the purpose-driven economy.

Students will work hands-on dealing with profit companies, hybrid companies, social enterprises, and non-profit organizations as a core and innovative part of the Lab, with the goal of mastering the evolution of sustainability and impact integration.

Finally, classroom-based, collaborative (small-group) sessions will provide students with an opportunity to apply concepts, methods, and tools acquired throughout the course

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:

- Understand challenges, functions, processes in a business and industrial environment and their mutual effects on business, economy, environment and society
- Develop new ideas and transformative solutions to deliver positive impact on business, industrial and societal scenarios evolving over time
- Interact in a professional, responsible, inclusive, effective and constructive way in a working environment, also motivating group members

Expected Learning Outcomes

At the end of the course, the student will gain the following skills:

- Ability to understand sustainable and social challenges and identify appropriate and innovative solutions, through an impact assessment of the options and a critical review of the results.
- Ability to analyse the role of technological innovations in meeting the emerging societal needs.
- Ability to understand a business scenario and develop solutions to improve social and sustainability impact by applying new impact strategies and assessing the implications in the short and long term.

- Ability to re-interpret the traditional managerial tools to manage the impact integration process
- Ability to apply different impact management models for different organization forms, to improve the scalability and non-financial performance.
- Ability to present solutions and ideas professionally and constructively, fostering the value of teamwork, and using a language adequate to both managers and fellow students.

Topics Covered

I – SUSTAINABILITY AND SOCIAL INNOVATION

- Introduction: sustainability and impact innovation
- The societal challenges and social economy

II –SUSTAINABILITY AND IMPACT MANAGEMENT

- Hybrid organizations
- New social business models
- Managing social tech Innovation
- The scaling strategies and the different tools
- The social and sustainable business model canvas

III – SUSTAINABILITY AND IMPACT MEASUREMENT

- The sustainability and impact measurement approaches, standards and tools
- The processes to manage and measure the impact

IV – TRAINING ARENA

- Group Project work: participation to real projects with profit companies, hybrid companies, social enterprises, not for-profit organizations

Bibliography

A Primer will be provided as well as additional readings and case studies during the course.

054954 Sustainable Manufacturing
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

The prerequisites know-how deals with the following topics:
- Design of manufacturing systems;
- Information systems;
- Operations management

Learning Objectives

The course fits into the overall program curriculum pursuing some of the defined general learning goals. In particular, the course contributes to the development of the following capabilities:
- Understand context, functions, processes in a business and industrial environment and the impact of those factors on business performance
- Identify trends, technologies and key methodologies in a specific domain (specialization streams)
- Design solutions applying a scientific and engineering approach (Analysis, Learning, Reasoning, and Modeling capability deriving from a solid and rigorous multidisciplinary background) to face problems and opportunities in a business and industrial environment

Expected Learning Outcomes

The main expected learning outcomes for each of the following capabilities are:
- Understand: the students will learn how the automation and digital technologies (i.e. Industry 4.0) are affecting the future manufacturing systems, both in the process industry as well as in the discrete manufacturing systems;
- Identify: the students will learn how to select (i.e. identify) the best technology and the best application scenario;
- Design: designing a manufacturing system is a complex process which requires to deal with the hard, soft and organizational dimensions of the design of the system. Quantitative and qualitative techniques will be explained. The impact evaluation will also be assessed in order to give students the know-how on how to understand the impact of their decisions.

Topics Covered

Part I – Introduction

- Advanced and Sustainable Manufacturing Strategies
    - Sustainable Development (social, environmental and economic megatrends
    - The importance of Manufacturing in the regional, national and global economy
    - Manufacturing as key enabler of the Europe's societal challenges

Part II – Competitive Advanced Manufacturing

- Advanced Manufacturing: Automation in the Process industry
    - Control
    - Typologies of control architecture (monitoring, direct digital control, supervisory control)
- Advanced Manufacturing: Automation in the Discrete Manufacturing industry
    - Design and management of Advanced Manufacturing Systems (AMS)
    - Real time control systems. Loading and dispatching
    - Soft computing techniques for the design and management of manufacturing systems
    - Industrial robots

Part III – Sustainable Manufacturing

- BOL-Energy- and Resource-efficient Manufacturing
    - Green and Customer-focused Manufacturing
    - Green Product Development
    - Sustainable Mass customization, Highly personalized production, Servitization in Manufacturing
    - Factory life-cycle concepts. Integrated design, modeling and multi-level simulation of an Energy Efficient Factory (i.e. machine energy states, energy value-stream mapping, Technical Building Services and building facilities)
    - Energy assessment: tools, audits, certification, KPIs,
    - Best available technologies (BATs)
    - Strategies for Energy optimization along the whole value chain (i.e. factories clustering, Industrial symbiosis, new business models, etc.)
    - Smart Manufacturing for Sustainability. ICT for Manufacturing
- BOL-Human-Centric and social sustainable manufacturing
    - Factory context and workers for human-centric workplaces. Skill and competence knowledge workers. Worker-centered and skill-oriented production planning and operation. Cognitive and symbiotic automation.
    - Design and co-evolution of the factory in relationships with social context (stakeholders such as local communities, other factories, policy makers, and training centres)
    - Assessment and practices of Social Sustainability
- End-of-Life Cycle Product Management
    - Strategies and Technologies for EOL in the different sector: Prevent, Re-use (re-manufacturing, dis-assembly, etc.), re-cycling, energy recovery, disposal
    - Tools and assessment methodologies (regulatory, social, environmental and economic dimensions) for the identification of the best strategy/technology. Qualitative and quantitative Decision Support Systems for Design and Planning. Performance measurements
    - Case studies in the automotive, aerospace, machine tools and electronics (including white goods) sectors
    - European and Italian Regulations
    - Product Life cycle knowledge for remanufacturing
    - Rare and critical material management (i.e. Urban mining)

Bibliography

No texts suggested.

056901 Systems and Methods for Big and Unstructured Data
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Students are expected to have basic knowledge of programming approaches and abstractions, distributed system architectures, relational databases, database design, entity-relationship models, SQL query language, and database programming (for relational databases). Basic knowledge of python is advised.

Learning Objectives

The objective of the course is to address the problems, solutions, methods, and technologies for big data storage and management, with special emphasis on scalability and persistency. The course is structured in three main parts. The first part covers the main principles and approaches of big data management, spanning issues like scalability, transactionality, and distribution of data. The second part covers the different approaches to unstructured data management, describing data models, query languages, and architectural solutions for non-relational data storage, also known as NoSQL solutions, spanning graph, columnar, documental, key-value, and IR-based databases. The third part discusses the design methodologies for the specification of NoSQL data models.

Expected Learning Outcomes

Students will learn the basic concepts of modern database approaches. They will become able to design, program, and use the different database methods, and they will learn how to select and adopt the best option depending on the business and technical requirements.

Students will learn how to:

- Identify problems that can be addressed with big data storage and processing techniques
- Apply the basic NoSQL technologies for real-world problems

Given specific project cases, students will be able to:

- Define and implement a big data solution for the problem
- Apply it on real datasets

Given specific project cases, students will be able to:

- Learn how to decide which data storage and processing solution to apply and how to evaluate this decision

Students will learn to:

- Write a report on a project describing and motivating the decisions taken and the results obtained
- Present their work in front of their colleagues and teachers

Students will learn how to develop a realistic unstructured data engineering project in all its phases

Topics Covered

The course content is organized in three main chapters:

1. Approaches to Big Data management

- Big Data problems and dimensions
- Data engineering and data science pipeline
- Enterprise-scale data management
- Scalability and persistency vs. volatility issues
- Cross-source data integration problems and architectures
- CAP theorem and implications. Non-relational distribution architectures
- Evolution of transactional properties: from ACID to BASE. Modern transactional architectures
- Data sharing and replication
- Cloud-based, scalable data processing and computing

2. Systems and Models for Big and Unstructured Data

- Graph databases
- Semantic databases
- Columnar databases
- Document-oriented databases
- Key-value databases
- IR-based databases

Each category of systems is covered along 5 dimensions: (1) data model (2) (declarative vs. imperative) query languages; (3) data distribution (4) non-functional aspects (5) architectural solutions.

3. Methods for the Design of Applications

- Modeling languages and methods for building unstructured data applications
- Design methodology within the data engineering pipeline
- Schema-less, implicit-schema, and schema-on-read approaches Green Product Development

Bibliography

Main textbooks

Sadalage, Fowler, NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence, Editore: Addison-Wesley, 2012

Marco Brambilla, Emanuele Della Valle, Andrea Tocchetti, et al., Course Notes, 2021

Recommended materials

Marting Kleppmann, Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems, Editore: O'Reilly, Anno edizione: 2017, ISBN: 978-1449373320

052537 Technologies for Information Systems
(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

The students are required to know the principles and methods of database design and technology, and the basic notions of the Entity-Relationship conceptual model and of the Relational Data Model along with its languages. The exams needed to acquire these notions are Data bases I and Data bases II (the latter may be attended in the same semester).

Learning Objectives

We are in the era of large, decentralized, distributed environments where the number of devices and data, and their heterogeneity, is getting out of control. Gartner reports that worldwide information volume is growing at a rate greater than 60% annually.

Organizations capture billions of bytes of data about their activities, users, operators, customers and suppliers, but their ability to collect, manage and interpret this information could be an obstacle to its use. The web is widening the range of data providers and consumers. Sensors, mobile devices and, in general, the IoT, produce further data that needs to be integrated and harmonized with the rest in order to produce value.

Decision-making is based on information, not just on data. More accurate information leads to better decisions and provides competitive advantages; hence processing, manipulating, and organizing data in a way that adds new knowledge has become a necessary issue.

The goal of the course is to enable students to master the engineering methods and processes that are necessary to manage modern information systems, and especially data-intensive systems, to operate on large data collections and to understand the utility and methods of business analysis, obtaining useful knowledge to improve the decision-making process.

As a consequence, we expose the students to some of the most advanced methodologies adopted to understand the conceptual and technological problems encountered in the design and implementation of "data products": tangible results based on analyses for complex systems, concentrating, as raw material, on collections of data that must be integrated, organized and analysed mainly through automatic tools.

In the belief that understanding is boosted by communication, this course is “Communication-Intensive”, in the sense that it aims at enhancing the students’ communication skills as applied to the technical content of the course, with a special emphasis on clarity and common ground (i.e. being able to take the interlocutors’ body of knowledge into proper account).

Expected Learning Outcomes

The students will learn how to:

- Identify the phases of Big Data management, from the choice of the data sources to the production of a “data product”

- Analyse the data sources and design a data integration system
- Design a data warehouse
- Identify the data quality problems encountered when managing heterogeneous collections of data

Given specific project cases, students will be able to:
- Detail the corresponding requirements
- Analyse and comment on specific conceptual and architectural choices
- Apply the theory to decide the most appropriate ones
- Develop data integration and data warehouse solutions fulfilling the high-level and design specifications.

Given a relatively complex problem, students will be able to:
- Analyse and understand the goals, assumptions and requirements associated with that problem and model them
- Define the type of architecture of the corresponding system
- Identify the appropriate conceptual and logical design methodology
- Estimate the system and the resources needed for its development

The students will learn to clearly explain a technological or methodological issue at the correct level of abstraction, considering the common ground with the interlocutor.

The students will learn how to develop a realistic data product.

Topics Covered

Information System Architectures and Heterogeneous Data Integration: structured and non-structured data (12 hrs lectures, 9 hrs exercises):
- Introduction to the architectures of modern information systems
- Basics of Data Integration: model heterogeneity, semantic heterogeneity at the schema level, heterogeneity at the data level
- Dynamic data integration: the use of wrappers, mediators, meta-models, ontologies,, etc.
- Lightweight data integration
- The future of data integration

Data Quality (2 hrs lectures)

Data Warehousing and Analysis (10 hrs lectures, 9 hrs exercises):
- Data Warehouse Architecture and querying
- Data Warehouse Conceptual Design
- Data Warehouse Logical Design
- Introduction to exploratory data analysis, data mining and its applications.

Communication Skills (2 hrs lectures, 6 hrs exercises)
- Basic elements of Communication Sciences (how to be clear)
- Common-ground Theory
- Writing skills

An optional project can be chosen by the students who want to improve their mark. The objective of the projects is to help students in applying the approaches and principles we teach in class. The students can ask to be assigned projects at any time of the whole academic year. Project artifacts can be released at any time of the academic year. The evaluation of projects will be based on the produced artifacts and on a report.

Bibliography

Main textbooks

AnHai Doan, Alon Halevy, and Zachary Ives, Principles of Data Integration, Editore: Morgan Kaufmann, 1st edition, Anno edition: 2012

M. Golfarelli, S. Rizzi, Data Warehouse Design: Modern Principles and Methodologies, Editore: McGraw Hill, Anno edition: 2009, ISBN: 0071610391

Recommended materials

Xin Luna Dong, Divesh Srivastava, Big Data Integration. Synthesis Lectures on Data Management, Editore: Morgan & Claypool Publishers, Anno edition: 2015, ISBN: 978-1-62705-223-8

M. Lenzerini, Data Integration: A Theoretical Perspective, Proceedings of ACM PODS, pp. 233-246, Editore: ACM, Anno edition: 2002, ISBN: 1-58113-507-6
Note: This is a scientific paper published in a volume of Conference proceedings

Clement T. Yu, Weiyi Meng, Principles of Database Query Processing for Advanced Applications, Editore: Morgan Kaufmann, Anno edition: 1998, ISBN: 1558604340
Note: (in The Morgan Kaufmann Series in Data Management Systems)

Roberto De Virgilio, Fausto Giunchiglia, Letizia Tanca (Eds.), Semantic Web Information Management - A Model-Based Perspective, Editore: Springer Verlag, Anno edition: 2009, ISBN: 978-3-642-04328-4

Pang-Ning Tan, Michael Steinbach, Vipin Kumar, Introduction to Data Mining , Editore: Addison-Wesley, Anno edition: 2006, ISBN: 0321321367 http://www-users.cs.umn.edu/~kumar/dmbook/index.php
Note: The web site contains a lot of interesting material

057252 Technology Risk Governance

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

No pre-requisites required.

Learning Objectives

Technology-driven businesses are nowadays struggling to keep up with the rapid pace of technology innovation and change, such as the increasing complexity of modern cyber-physical systems. In this context, Technology Risk Governance (TRG) comprises the set of strategies, methods and organisational models that different organisations put in place for understanding, assessing and managing technology-related risks. This course aims at transferring to students theoretical and practical knowledge on TRG through in class discussion of real cases and testimonials from companies, which will cover a wide spectrum of industrial and service systems (e.g. manufacturing, energy, transport).

The course addresses the state-of-the-art approaches, methods and models for supporting risk-informed decisions in managing complex socio-technical systems, from technology selection to system design, from organisational risk factors to regulation and governance.

Expected Learning Outcomes

After successful completion of this course module students:

- Will demonstrate the ability of identifying and analysing technology risks in cyber-physical systems, eventually discussing alternative mitigation options (Knowledge and understanding);
- Will be able to select and apply proper qualitative and quantitative technology risk assessment methods at different system life cycle stages (Applying Knowledge and understanding);
- Will be able to identify and critically discuss emerging relevant challenges to the governance of technology risks in cyber-physical systems, leveraging on state-of-the art knowledge (Making Judgements and Learning skills), and prepare a technical report on technology risk assessment (Communication).

Topics Covered

The course addresses the state-of-the-art approaches, methods and models for supporting risk-informed decisions in managing complex socio-technical systems, from technology selection to system design, from organisational risk factors to regulation and governance. More specifically:

- Risk governance of new and emerging technologies. Technology outlook and risk assessment methods for technology foresight and selection. Discussion of application cases.
- Risk analysis of complex socio-technical systems. Risk definition, modelling and reporting under the precautionary principle; Risk engineering methods (with exercises

on FMECA, FTA-ETA, PRA). Safety and information security analysis of cyber-physical systems: differences and relationships.

- Human and Organisational risks in complex socio-technical systems. Modelling and analysis of human and organisational risk factors; Risk Management of safety-critical and mission-critical systems (the High Reliability Organisation theory). Critical incident analysis case discussion. Discussion of industrial practices; Testimonials.
- Risk governance of interdependent systems. Characteristics of networked cyber-physical systems. Types of interdependencies. Modelling tools for vulnerability and interdependency analysis. Risk governance models and processes, discussion of cases and testimonials from companies.

The learning experience of this course includes, in addition to face-to-face lectures, numerical exercises, case discussions, a group project, real examples and interactions with guest speakers from industry.

Bibliography

Main textbooks

Course instructor, Teaching notes, Case texts and suggested readings
Note: Available on Beep course web page

Recommended materials

Bedford, Tim & Cooke, Roger M, Probabilistic risk analysis: foundations and methods, Editore: Cambridge University Press, Anno edition:
2012 https://www.cambridge.org/core/books/probabilistic-risk-analysis/E7AB7D462EA12249CA33D828B6A44ECF

Reason J. T., Managing the risks of organizational accidents, Editore: Routledge-Ashgate, Anno edition: 1997

056829 The Social Shaping of Technology
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

No pre-requisites required.

Learning Objectives

Technology is one of the most pervasive features of modern society and the impact of technology on society has been a topic of longstanding concern. This course cultivates a critical approach to technology that highlights how technological objects, both old and new, are shaped by the social and cultural contexts in which they are designed, manufactured, and used.

In the first module students are introduced to a corpus of scholarship that looks at how social relations and society shape technology and get 'inside technology', which highlights how the very design of technology (including the artifacts themselves) embodies important social, cultural, ethical, and political assumptions that inform how we use, value, or reject technology. Readings will examine some of the recent work by sociologists, anthropologists, historians, philosophers as well as feminists and postcolonial scholars who have provided new insights into our understanding of the development and dissemination of technology. Throughout we will look at studies of various technologies, such as bridges, the bicycle, the microwave, birth control, financial markets, and the internet.

In the second module students will apply the conceptual and methodological tools from the discussed literature in a case study of a contemporary or emerging technology. This will allow for a more in-depth exploration of the conceptual framework provided in the first module through the examination of the particular issues and concerns related to a specific technology. Students will critically examine how their selected technology shapes and is shaped by the social context in which it is produced and consumed, and what are the implications of these processes. During this second module students are expected to play a more interactive, collaborative, and participatory role by engaging in class discussions, writing exercises, presentations, and peer review.

Expected Learning Outcomes

Students will:

- Acquire a broad critical perspective on the ethical and social impacts and implications of technology
- Learn how to recognize and analyse ethical and social aspects and issues inherent to old and emerging technologies;
- Be able to understand how technical problems are informed by the socio-cultural contexts in which they occur.
- Be able to use critical skills in identifying and analyzing technological case studies;
- Be able to apply sociological theories to problems created, aggravated or transformed by technologies;

- Be able to explore and assess possibilities for addressing social problems generated by technologies.
- Be able to independently analyse the social impact of a technology and the social processes that inform technological development and use;
- Be able to evaluate and select the appropriate critical approaches to understanding and addressing social problems generated by technology.
- Learn to exercise and improve their scholarly writing skills;
- Learn to present the results of their independent research in an effective manner;
- Learn to justify their arguments clearly and coherently
- Be better prepared for their future professional life as a critical thinker and communicator;
- Be better able to engage critically with issues that affect the society they live in;
- Be better able to analyse problems through a theoretical lens.

Topics Covered

The course is structured in two modules of approximately the same length:

- Module 1 consists of a series of interactive lectures dealing with major topics in social studies of technology. Students are required to come to class prepared and expected to actively participate. Lectures will discuss a number of approaches central to a critical examination of technology, such as the Social Construction of Technology (SCOT), Feminist and Postcolonial studies of Technology, Actor-Network Theory (ANT), and Disability Studies. Students will also be introduced to several key conceptual and methodological approaches to technology studies, such as the role of technoscientific controversies, accidents and disasters; studies of maintenance and repair; technological determinism; interpretive flexibility; the agency of artifacts; scripts and affordances; and cyborg embodiment.
- Module 2 consists of case studies on contemporary and emerging technologies that students can self-select. Rather than focusing on the technical aspects of a certain technology, students are expected to focus on the social, ethical, and political dimensions of their case studies. This part of the course will be carried out in the form of symposia, in which students will have to collaborate, discuss, and present in small groups (according to the 'flipped classroom' method).

Bibliography

Main textbooks

H.M. Collins & T. Pinch, The Golem at Large: What you should know about technology

Bruno Latour, Where are the Missing Masses? Sociology of a Few Mundane Artefacts
Note: In W. Bijker and J. Law (Eds.) (1992) Shaping Technology, Building Society: Studies in Sociotechnical Change (pp. 225-258).

Ron Kline, Technological Determinism
Note: In International Encyclopaedia of the Social & Behavioural Sciences, 2001 (pp. 15495-15498)

Leo Marx, Does Improved Technology Mean Progress?
Note: (1987) Technology Review, 71, 33-41.

Kline, R. & Pinch, T (1996)., Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States.
Note: Technology and Culture, 37(4), 763-795.

David, P.A., Clio and the Economics of QWERTY
Note: (1985). The American Economic Review, 75(2), 332-337.

Judy Wajcman, Feminist Theories of Technology
Note: (2010). Cambridge Journal of Economics, 34, 143-152.
Couldry, N., Mejias, The Costs of Connection: How Data is Colonizing Human Life and Appropriating It for Capitalism
Note: (2019). Stanford University Press
Nakamura, L., Indigenous Circuits: Navajo Women and the Racialization of Early Electronic Manufacture
Note: (2014). American Quarterly 66(4), 919-941
Audre Lorde, The Master's Tools Will Never Dismantle the Master's House.
Note: 1983
David Edgerton, The Shock of the Old: Technology and Global History Since 1900
Note: 2007
Noortje Marres, The Costs of Public Involvement: Everyday devices of carbon accounting and the materialization of participation.
Note: (2011). Economy and Society, 40(4), 510-533.
Langdon Winner, Do Artifacts Have Politics?
Note: 1986
David F Noble, Social Choice in Machine Design: The Case of Automatically Controlled Machine Tools
Judy Wajcman, Technofeminism
Note: 2004

059116 Transdisciplinary Projects For Health and Social Challenges
(5 ECTS credits)

The course is offered in the:

Spring Semester (Feb – May)

Prerequisites

The course will be delivered in English. However, to perform basic tasks (e.g., interacting with the organizations that proposed the challenges, reading material made available by the organizations, interviewing potential users, etc.) a B1 level in Italian language according to the "Common European Framework of Reference for Languages" is advised.

The course has limited available places (up to 20 students from Biomedical Engineering and up to 20 students from Management Engineering) to guarantee the coordination of project-related activities and high-quality supervision. Eligibility criteria and enrolment modalities are available here:

https://www.ccsbio.polimi.it/corso/laurea-magistrale/#Corsi_Inter_CS_e_Capstone_Project.

Learning Objectives

This subject aims to teach students how to be critical thinkers able to apply their knowledge to solve real-life challenges within the SDG3 - Good Health and Wellbeing framework. Proponent organizations like social enterprises, not-for-profit organizations, foundations, patient advocacy groups, and voluntary associations will offer challenges. The proponent organization will define the specific objectives and expected results (project briefs) that should be addressed.

Students will work in small interdisciplinary teams composed of biomedical and management engineering Students under the joint supervision of one tutor from Politecnico and another from the proponent organization.

Solving the real-life challenge will require combining biomedical and management competencies. From the biomedical side, teams will be challenged to develop a feasibility study, a mock-up, or a prototype (coherently to the specific challenge), having the opportunity to get continuous access to a dedicated laboratory at the Leonardo Campus. From the management perspective, teams will be challenged to define the user requirements through a design-thinking approach, develop an optimal service design and business model for their solution, and run a health technology assessment exercise to inform decision-makers at different levels.

During the semester, Students will participate in a kick-off meeting at Fondazione Triulza, will participate in two interim review meetings without evaluation to collect feedback from the faculty, and a final presentation of the solutions at Fondazione Triulza with the participation of all proponent organizations.

Working on real-life challenges in small interdisciplinary teams will help Students develop i) a sense of personal responsibility concerning the project goals, ii) the ability to collaborate with peers and lead team members to meet deadlines and expectations, and iii) the necessary communication skills.

The course involves two innovative teaching CFUs.

Expected Learning Outcomes

Students must acquire specific competencies according to the following Dublin Descriptors:

1 - KNOWLEDGE AND UNDERSTANDING

Students will learn how to develop a solution from a real-life challenge by understanding the needs of all actors, formalizing user requirements, designing prototypes (TRL 3/4), and designing a service and business model within a limited timeframe.

2 - APPLYING KNOWLEDGE AND UNDERSTANDING

Given a specific project, Students will be able to:

- gather insights from external advisors
- plan team activities to meet deadlines and milestones as well as expectations
- define functional requirements and technical specifications
- design and (eventually) test the solution/prototype that has been developed

3 - MAKING JUDGEMENT

Given the complexity of the real-life challenge, Students will be able to:

- develop self-assessment abilities
- improve collaboration skills and responsibility on assigned tasks
- estimate the resources needed for developing the proposed solution, identify risks of different natures and define mitigation actions

4 - COMMUNICATION SKILLS

Students will learn to:

- improve their communication skills by presenting their work to peers and both the proponent organization and the academic tutor
- disseminate the results of their project to a large audience

5 - LIFELONG LEARNING SKILLS

Students will learn:

- how to develop a solution to a real-life challenge proposed by an external organization
- how to contribute to a multidisciplinary team and respect a time-constrained Gantt of activities

Topics Covered

On the first day, students will receive a list of available challenges, each of which will have specific goals and tasks. Students can choose their top four preferences and also mention their least preferred challenge. The lecturer will form teams, and each team will be advised by both a supervisor from a proponent entity and an academic tutor.

The lessons will focus on creating a common ground among students from different topics such as need assessment, medical device regulation (MDR), privacy and data valorization in healthcare, project management, health technology assessment, and business models. Several hours will be dedicated to developing solutions or prototypes for health and social challenges. Teams will have two interim meetings to review progress and discuss any issues. The final solution/prototype will be presented by each team at an event.

Sustainable Development Goals (SDGs)

This course contributes to achieve the following Sustainable Development Goals:

- **SDG3 - GOOD HEALTH AND WELLBEING**
  (Proponent organizations like social enterprises, not-for-profit organizations, foundations, patient advocacy groups, voluntary associations, etc., will propose health and social challenges in the SDG3 – Good Health and Wellbeing framework. In light of this, the entire course (125h) addresses challenges related to SGD3 with a particular focus on target 3.8 – namely, “achieve universal health coverage, including financial risk protection, access to quality essential healthcare services and access to safe, effective, quality and affordable essential medicines and vaccines for all”)

Bibliography

No texts suggested.

057050 Vision and Change

(5 ECTS credits)

The course is offered in the:

Fall Semester (Sep – Dec)

Prerequisites

Students should be prepared to explore the 3 primary course themes:

- Vision as Meaning: In light of the plethora of wicked problems of our era, the United Nations' (UN's) created 17 Sustainable Development Goals (SDGs). Responding to these goals requires a shared vision of a preferred future, and even a better world. As futurist Fred Polak wrote in 1973, The rise and fall of images of the future precedes or accompanies the rise and fall of cultures. As long as a society's image is positive and flourishing, the flower of culture is in full bloom. Once the image begins to decay and lose its vitality, however, the culture does not long survive." Meaningful visions are much deeper than the surface representations of imagery, storytelling and even data-based projections. They actually have information encoded in the neuronal, regional, and social neurological networks. Becoming aware of these networks, and engaging them actively, will open new vistas on creating visions with meaning
- Design as Inquiry: Ezio Manzini writes, "…in the transition toward a networked and sustainable society, all design is (or should be) a design research activity and should promote sociotechnical experiments" (Manzini 2015). Design is a powerful tool for collective inquiry because of its explicit making and implicit materiality. Anthropologist Lambros Malafouris refers to the personal meaning embedded within objects aligns with the concept of Material Engagement Theory (MET). Resonating in the notion of "type" in architecture, when objects contain both personal and shared meaning. By reinforcing the neurological realities of boundary objects, design is not only essential to communicate meaning, but also as collective inquiry. Students will collaboratively design experiments to encourage practitioners and stakeholders toward collective making of shared meaning.
- Change as Transition: Transitioning to preferred states requires not only systemic understanding and action, but a rebalancing of how we think about leadership and organizations in terms of design, infrastructure, and culture. Terry Irwin and Gideon Kossoff of the Transition Design Institute at Carnegie-Mellon visualize the challenges faced by stakeholders in adaptive situations in order to inform coherent responses to crises. This stage of the course will explore the variety of emerging frameworks for cultivating change in sociotechnical environments. Students will explore how to cultivate a collective consciousness that encourages stakeholders to transition toward a more viable world. Ideally the outcome of course will also reveal insights on the desired transitions for personal transformation.

Preparation is primarily an interest in exploring these 3 themes, in addition to familiarity or desire to learn the topic content.

Learning Objectives

Design experiments within a sustainable development goal (SDG), and speculatively test them in sociotechnical systems in order to reveal insights that inform new models for thought and practice.

Expected Learning Outcomes

The experiments should demonstrate a scientific approach (Collaborative Inquiry, Action Research, Design Research, Speculative Design) and reveal data deriving from the realities and opportunities in complex environments. The models should demonstrate a strong understanding and capability with multiple design practices and making capabilities in accelerating design research projects [Vision & Change Research Portfolio].

Topics Covered

As society faces significant challenges, the need for transformative innovation has never been more vital. Anyone who seeks a transition to more sustainable practices needs a meaningful vision of a preferred future. However, merely envisioning and visualizing a future is not sufficient to stimulate change in sociotechnical systems in the context of todays wicked problems. Given their complexity, new meaningful visions must trigger neurological changes in perception, aspiration and motivation. In addition, personal awareness, reflection and resilience are becoming the essential traits to steward change.

Vision & Change offers innovation management students and practitioners, and designers interested in facilitating transitions, an opportunity to explore and learn from recent research in transformation, IDeaLs. Students will articulate visions of more sustainable practices that simultaneously trigger reflections for personal change. Rather than pursue actual business challenges and predetermined taxonomies, students will design and speculate new techniques and tools that reveal more meaningful insights into the sociotechnical systems at play. This pedagogy will encourage speculation and experimentation necessary for personal, organizational and societal change.

Vision & Change will primarily use Strategic Foresight and Design Inquiry to inspire personal transformation (towards presence, purpose, and resilience) by developing new meaningful visions (that reflect a change in perception, aspiration and motivation). To this aim, we will explore and prototype approaches to engage people to make transformative innovation happen, first by imagining visions of more meaningful futures, then designing tools for embodied experiences that ideally will inform how to bring people together to collectively change the existing situation into a preferred one.

More specifically, Vision & Change will begin by circumscribing spaces for design speculation and research within the UN`s Sustainable Development Goals. From within this sociotechnical context, recent insights from neuroscience, anthropology and social sciences will ground the design theory guiding student`s designs of speculative experiments. The final part of the course will expect students to create their own taxonomies to developing visions and accelerating change. The course will intentionally avoid a linear methodology in favour of developing a diverse set of perspectives and approaches, similar to the spirit of the experiments conducted within the IDeaLs platform.

To map the students' journey through the course, a research "portfolio" will document meaningful observations, insights, sketches and other speculations, which will be submitted for final grading. The portfolio should be a creative visual exercise, and as such should also reflect the personal transition towards presence, purpose, and resilience, in the most appropriate format.

Bibliography

Main textbooks

IDeaLs (Innovation and Design as Leadership): Transformation in the digital era, ISBN: 9781800718340
Note: Part I is required reading for course section Vision as Meaning
Collaborative Inquiry for Organization Development and Change, ISBN: 9781800378247
Note: Required reading for Part II Design as Inquiry
IDeaLs (Innovation and Design as Leadership) Transformation in the Digital Era, ISBN: 9781800718340
Note: Part III is required reading for course section Change as Transition

Recommended materials

Research for designers: a guide to methods and practice, ISBN: 9781446275146
Note: optional reading for Part II Design as Inquiry
Speculative everything: Design, fiction, and social dreaming, ISBN: 9780262019842
Note: optional reading for Part II Design as Inquiry
Design research: Methods and perspectives, ISBN: 9780262122634
Note: optional reading for Part II Design as Inquiry
Design unbound: Designing for emergence in a white-water world., ISBN: 9780262535793
Note: reading for Part III Change as Transition