SHAKE THE FUTURE.

CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

INDUSTRIAL ENGINEERING

AGILE FACTORY MANAGEMENT

YEAR 1
SPRING SEMESTER

PROGRAMME SUPERVISORS:
FAROUK BELKADI, ALAIN BERNARD

Établissement public sous tutelle du ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation

GROUPE CENTRALE

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SYSTEMS ENGINEERING

INDUSTRIAL ENGINEERING – AGILE FACTORY MANAGEMENT

YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Farouk Belkadi – *farouk.belkadi@ec-nantes.fr*

Objectives

At the end of the course (30 hours + personal work) the students will be able to:

- Understand the principles of systems engineering, main processes and standards
- Conduct requirement collection and traceability
- Create SysML models within a Systems Engineering perspective
- Conduct Model Based Systems Engineering approach with SysML

Course contents

These introductory lectures aim to present the main methods and tools of Systems Engineering as used in industry for the development of new complex systems. The course commences with an introduction to the main foundations of systems engineering, summarizing its main processes and presenting the potential organizations working on SE standards. After this introduction, SysML language is explored to illustrate how this modelling tool is used along the SE process. The following elements will be covered:

- Introduction to the concept of system and system of systems
    - What is a system? What is a system of systems
    - System analysis foundations with the concept of facet:
        - Core features; system lifecycle; business models and system decomposition
        - The design process and the concept of facet

- Systems Engineering (SE)
    - Definition of systems engineering
        - Definitions from the standards
        - Main characteristics of SE
    - Overview of main SE processes
        - Processes from the standards
        - Key Systems Engineering methods (Ve cycle, Waterfall, incremental, etc.)
    - Requirement management and functional analysis
        - The concept of requirement?
        - The requirement engineering and management process
        - From requirement engineering to functional analysis
    - Design of systems architecture:
        - Concepts of functional (logical) and physical architecture.
        - Function allocation and design matrix
        - Modular architecture and Interface management
        - The RFLP approach

- System design and analysis with SysML language
    - Main concepts of SysML
    - Requirements management: Requirement diagram, Use Case diagram,
    - Behavior analysis: Sequence diagram, State-Transition diagram, activity diagram
    - Structure definition: Bloc definition diagram, Internal bloc diagram
    - Connection between diagrams within a MBSE perspective
- Deploying a Model Based Systems Engineering (MBSE) approach
    - What is MBSE?
    - Practice and mini project on Eclipse Papyrus software
- Overview of research work on systems engineering

Practical exercises and homework will help students to apply the learned modelling languages to several case studies. A presentation from an industrial partner is planned to discover the current industrial practices. A mini-project is also planned as a collaborative development project of an information system dealing with real industrial use cases.

Course material

- Kossiakoff, A., Sweet, W. N., Seymour, S. J., & Biemer, S. M. (2011). Systems engineering principles and practice (Vol. 83). John Wiley & Sons.
- Systems Engineering Fundamentals. DEFENSE ACQUISITION UNIVERSITY PRESS, FORT BELVOIR, VIRGINIA 22060-5565
- Mark Austin Introduction to Systems Engineering, ENES 489P Hands-On Systems Engineering Projects. Institute for Systems Research, University of Maryland, College Park
- Roland Renier, Raphaël Chenouard. De sysml à modelica: *aide à la Formalisation de modèles de Simulation en conception*. 12ème Colloque National AIP PRIMECA Le Mont Dore - 29 March to 1 April 2011
- Hubert Kadima. *Méthodes et outils d'ingénierie de systèmes mécatroniques fiables*; Journée Gdr MACS du 03.05.2010 –SupMéca Paris

Keywords

SE processes; SE standards; SysML, requirement engineering, RFLP approach, Eclipse Papyrus

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	10 hrs	0 hrs	12 hrs	8 hrs	2 hrs

STATISTICS AND DATA ANALYSIS

INDUSTRIAL ENGINEERING – AGILE FACTORY MANAGEMENT

YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Evans Gouno; *evans.gouno@univ-ubs.fr*

Objectives

The aim of this course is to provide the students with the necessary mathematical tools to address the fields of Reliability and Quality Control.
The first part of the course introduces the elements of probability.
The second part focuses on Stochastic methods, Markov Chains and Reliability models, with many applications in science, engineering and beyond.

Course contents

- Part 1: Probability (16h)
  - Basics of probability
  - Random variables
  - Special distributions
- Part 2: Stochastic Processes (14h)
  - Introduction
  - Markov chains.
  - Poisson Processes.
  - Birth-death processes.
  - Generalized Markov models.
  - Applications of Markov chains.

Course material

- Pitman, J. (2006) Probability, Springer
- Larsen R.J., Marx, Morris, L.M. (2012) Mathematical Statistics and Its Applications, Pearson (Chapter 1-4)
- Vidyadhar G. Kulkarni (2010) Modeling and analysis of stochastic systems, 2nd ed., Chapman & Hall, Boca Raton, FL, 2010 (QA274.3 K84)
- Ross, Sheldon M., (1982). Stochastic Processes, New York: John Wiley & Sons (QA274 R65 1983)
- Ghahramani, S (2005). Fundamentals of probability with stochastic processes. 3rd ed. Prentice Hall: New Jersey. (QA273 G42 2005)
- Jean-C F. (2003) Lectures in elementary probability theory and stochastic processes, McGraw-Hill, New York (QA273 F33 2003)

Keywords

Random variable, Expectation, Probability density function, Moment generating function, combination of random variables, Stochastic Processes, Markov chains, Poisson Processes.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	12 hrs	14 hrs	0 hrs	4 hrs	2 hrs

MANAGEMENT SYSTEMS AND SOCIO-ORGANIZATIONAL ASPECTS FOR INDUSTRIAL ENGINEERING

INDUSTRIAL ENGINEERING – AGILE FACTORY MANAGEMENT

YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Rima Ayoub, *Rima.ayoub01@gmail.com*

Objectives

The purpose of this course is to explain the main factors impacting the behavior of the firm. The first part (Management systems) introduces concepts and methods to analyze the internal and external environment of an organization. Tools like SWOT and PESTEL will be studied to show how they help managers make decisions in complex socio-economic contexts.

In the second part (socio-organizational aspects), some fundamental behavioral science concepts will be reviewed to illustrate how they can be effectively used in organizations. Through the course, students will gain an understanding of individuals and how they behave within organizations and how groups work together. Issues and dilemmas faced by organizations in these areas will be explained.

Course contents

Management Systems:

- Understand strategy and strategic management
- Explore concepts and methods of scanning the external and internal environment of a firm: (PESTEL, SWOT, Porter's Five +1Forces, etc.)
- Understand how to explore and exploit a firm's capacities
- Acquire knowledge about alternative strategies to acquire and maintain competitive advantages
- Acquire knowledge, within the strategic management process, about choices at both corporate and business levels
- Understand and analyze the deployment of strategic choices: implementation, assessment and controlling actions

Socio-Organizational Aspects:

- Understand the socio-organizational aspects involved in the main processes of rationalizing production systems.
- Mastering the sociological and economic dimension of the processes of rationalizing production systems.
- Understand the theories, frameworks and concepts used to explain how and why individuals and groups act the way they do in organizations
- Learning concepts, methodology, and issues of some main Organization Science Models.

Exercises will be completed during and between classes.

Course material

Organization of the firm:

- Mc Shane S. L., Von Glinow M. A., Organizational Behavior, Mc Graw-Hill, 4th Edition, 2008
- Henry Mintzberg (1989). Mintzberg on Management: Inside Our Strange World of Organizations
- Crozier, Michel & Friedberg, Erhard. Actors and Systems (Chicago: University of Chicago Press, 1980).
- March J.G. and Simon, H.A. (1958), Organizations, New York: Wiley, 1958.
- Peter Drucker, The Age of Discontinuity, Heineman, 1968
- Walter Natemeyer , Paul Hersey, Classics of Organizational Behavior (1995), Fourth edition, Waveland Press, 2011

Management Control Systems:

- Belkadi et al., (2017) PSS Pattern concept for knowledge representation in design process of industrial product-service systems, Procedia CIRP
- Berliner C.and Brimson J. (1988). Cost management for today's advanced manufacturing, the CAM-I conceptual design, Harvard Business School Press.
- Johnson H.T. (1992) Relevance regained, from Top-down control to Bottom-up empowerment, Free Press
- Johnson H.T. and Kaplan R.S. (1987) Relevance lost: the rise and fall of management accounting, Boston, Harvard Business School Press
- Malmi T. and Brown D. (2008). « Management Control systems as a package – Opportunities, challenges and research directions», Management Accounting Research, vol. 19, N°4, p. 287-300.
- Vargo S. and Lusch R. (2008). « Service-dominant logic: continuing the evolution », Journal of the Academy of marketing Science, vol. 36, n° 1, p. 1-10.

Keywords

Applied behavioral, Organizational models, Contingency theory, science Management control system, Performance, efficiency, costing

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	20 hrs	6 hrs	0 hrs	4 hrs	2 hrs

STOCHASTIC AND MULTI-AGENT SIMULATION

INDUSTRIAL ENGINEERING – AGILE FACTORY MANAGEMENT

YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Pierre CASTAGNA, *pierre.castagna@univ-nantes.fr*

Objectives

At the end of the course (30 hours + personal work) the students will be able to:

- Simulate random phenomena in discrete-event simulation
- Analyse the results of a stochastic simulation
- Understand the basics of multi-agent simulations
- Design multi-agent systems and evaluate their performance on given scenarios

Course contents

These lectures are split into two separate courses:

The first expands upon the lectures in discrete-event simulation given in the Autumn semester. It aims to introduce the concepts of stochastic simulation, and involves two main questions:

- How are random phenomena modelled in discrete-event simulation?
- How are the results of a stochastic simulation meant to be analysed?

The second part introduces a separate approach to complex discrete-event systems simulation: the multi-agent approach. The following questions will be answered:

- What are the main pillars of Multi-agent simulation?
- What is the best design methodology of multi-agent models?

After an introduction lecture, practical sessions will lead to a mini-project in full autonomy. Industrial software such as Rockwell Arena, Netlog or Anylogic will be used.

Course material

- Introduction to Simulation Using SIMAN, Pegden, C.D., Sadowski, R.P., Shannon, R.E., 2nd ed. McGraw-Hill, Inc., New York, NY, USA (1995)
- Stochastic simulation: algorithms and analysis, Asmussen, S., Glynn, P. W., Vol. 57. Springer Science & Business Media (2007)
- Multiagent Systems, G. Weiss, 2nd ed. MIT Press, Cambridge, MA, USA (2013)
- The big book of simulation modeling: multimethod modeling with AnyLogic 6, Borshchev, A., AnyLogic North America (2013).

Keywords

Stochastic simulation; Multi-Agent Systems; Discrete-event simulation; Results analysis

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	8 hrs	0 hrs	14 hrs	8 hrs	2 hrs

MODELLING OF COMPLEX SYSTEMS (2)

INDUSTRIAL ENGINEERING – AGILE FACTORY MANAGEMENT

YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Alain Bernard, *alain.bernard@ec-nantes.fr*

Objectives

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

- Apply the main concepts of the first part of the course (Modeling of complex systems (1))
- Use the languages learned during the first semester in terms of complex system modelling
- Analyze the requirements of modelling a complex system
- Understand the different roles of stakeholders and propose a collaborative organisation
- Build a conceptual model of process by using different languages
- Build a conceptual model of data by using different languages
- Define the universal, vernacular and vehicular features needed to communicate between the different stakeholders with different roles in different domains
- Propose a complete and coordinated solution (mostly the system architecture) for the definition of an integrated information system.

Course contents

This second part of the course relates to a collaborative mini-project.
Based on the different concepts learned in different courses (Modelling of complex systems (1), Enterprise modelling, Systems Engineering), the students will be divided in groups of two students that will have a given role in the project. They will have to organise their own activities and also to collaborate and interact with the other groups and the other stakeholders of the project.
They will present their progress during a mid-term workshop and during a final workshop.
This mini-project will be complementary with another mini-project in the Systems Engineering course whose objective will be to structure a complete systems engineering modelling process.

Course material

- Modeling of Complex Systems, An Introduction, V. Vemuri and J. William Schmidt, ISBN: 978-0-12-716550-9
- Complexity in engineering design and manufacturing, lecture M1-I-ENG semester 1, Alain Bernard
- Systems Design and Analysis: General purposes and case studies, lecture M1-I-ENG semester 1, Alain Bernard
- Process/Data Modeling for Additive Manufacturing Value Chain Analysis, lecture M1-I-ENG semester 1, Alain Bernard
- Complexity-based modeling of reconfigurable collaborations in production industry, G. Schuh, L. Monostori, B.Cs. Csaj, S. Döring, CIRP Annals - Manufacturing Technology 57 (2008) 445–450
- Complexity in engineering design and manufacturing, Waguih ElMaraghy, Hoda ElMaraghy, Tetsuo Tomiyama, Laszlo Monostori, CIRP Annals - Manufacturing Technology 61 (2012) 793–814
- Complexity of Multi-Disciplinary Design, T. Tomiyama, V. D'Amelio, J. Urbanic, W. ElMaraghy, CIRP Annals – Manufacturing Technology 56 (2007) Issue 1, 185-188

- Integration of a working situation model for training and simulation during design and industrialisation of a system, M. Shahrokhi, PhD thesis, Ecole Centrale Nantes, 12 December 2006
- Manufacturing Systems Configuration Complexity, H. A. ElMaraghy (1), O. Kuzgunkaya, R. J. Urbanic, CIRP Annals - Manufacturing Technology, 54 (2005) Issue 1, 445-450

Keywords

Complex systems, modelling languages, conceptual models, information system architecture

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	0 hrs	10 hrs	0 hrs	20 hrs	2 hrs

INNOVATION ENGINEERING

INDUSTRIAL ENGINEERING – AGILE FACTORY MANAGEMENT

YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Xavier Lesage, *xavier.lesage@essca.fr*

Objectives

At the end of the course (30 hours + personal work) the students will be able to:

- Understand and practice a customer-oriented and a value-driven process to assess a business opportunity
- Conduct activities associated with business planning and business modelling
- Assess the underlying dimensions of a business plan
- Leverage tools and methodologies of strategic communication

Course contents

These introductory lectures aim to present a set of methods and tools used in the development of a business opportunity and how such development projects are managed and drive innovation. Based on active learning techniques, students will be tasked with conducting an entrepreneurial project. The concepts will be introduced along the process of business modelling of the innovation. At the end of the course, students will be confronted with the strategic communication of their entrepreneurial project by putting together a pitch and a business plan.

The following items will be presented in detail:

- Introduction to innovation engineering
- Value creation behind a business opportunity: from a problem to a value creation process
- Prototyping a solution
- Business model
    - Monetizing a value proposition
    - The business system behind the value proposition
- The R&D roadmapping
- Financial plans and need for funds
- Strategic communication
    - Pitch Communication
    - Business Plan Structure

Course material

- "Guide to Business Plan Writing," Gate2Growth supported by European Commission
- Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers
- Value Proposition Design: How to Create Products and Services Customers Want
- Other resources will be available on Moodle

Keywords

Startup – Business Process – Business Model – Roadmapping – Business Plan – Customer-driven

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	12 hrs	0 hrs	8 hrs	10 hrs	2 hrs

CONFERENCES / INTRODUCTION TO RESEARCH

INDUSTRIAL ENGINEERING – AGILE FACTORY MANAGEMENT
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Farouk Belkadi, *farouk.belkadi@ec-nantes.fr*

Objectives

Discovery of research via conferences and research papers.

Course contents

Students will attend, where possible, locally held research conferences. Time will be set aside for summarising scientific publications.

Course material

Keywords

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	2	hrs	hrs	hrs	hrs	0 hrs

MODERN LANGUAGES - FRENCH

INDUSTRIAL ENGINEERING – AGILE FACTORY MANAGEMENT

YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Silvia Ertl – *silvia.ertl@ec-nantes.fr*

Objectives

The objective is to familiarize the learner with the French language and French culture through an entertaining task-based communicative language teaching, focused on speaking combined with:

- Phonetics
- Self-correcting exercises on our learning platform
- Learning Lab activities
- Project work
- Tutoring

Course objectives include the acquisition and reinforcement of vocabulary, syntax, and pronunciation by both traditional means and through the use of digital resources. Students will learn general French, develop language skills of oral and written comprehension and expression.

After completing this course (32 hours + personal work), the students will be able to communicate in spoken and written French, in a simple, but clear manner, on familiar topics in the context of study, hobbies etc. Another important goal of this course is to introduce the student to French culture. At the end of the course (2 semesters), complete beginners can achieve an A1 level and some aspects of the A2 of The Common European Framework of Reference for Languages. More advanced students may aim for B1/B2 levels.

Course contents

Full range of practical communication language exercises: reading comprehension, listening comprehension, written expression, oral expression.

Learners will be able to use the foreign language in a simple way for the following purposes:

1. Giving and obtaining factual information:
   - personal information (e.g. name, address, place of origin, date of birth, education, occupation)
   - non-personal information (e.g. about places and how to get there, time of day, various facilities and services, rules and regulations, opening hours, where and what to eat, etc.)

2. Establishing and maintaining social and professional contacts, particularly:
   - meeting people and making acquaintances
   - extending invitations and reacting to being invited
   - proposing/arranging a course of action
   - exchanging information, views, feelings, wishes, concerning matters of common interest, particularly those relating to personal life and circumstances, living conditions and environment, educational/occupational activities and interests, leisure activities and social life

3. Carrying out certain transactions:
    - making arrangements (planning, tickets, reservations, etc.) for travel, accommodation, appointments, leisure activities
    - making purchases
    - ordering food and drink

Course material

Course material: Preparation manuals, our own tailor-made documents, written and televised press, internet, general civilization documents, digital tools, our own educational materials on Hippocampus (Moodle).

Keywords

reception (listening and reading), production (spoken and written), interaction (spoken and written), knowledge, skills, linguistic competence, sociolinguistic competence, pragmatic competence, register, cultural differences, non-verbal communication

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
French	4	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

MODERN LANGUAGES - CULTURAL AND COMMUNICATIONAL ENGLISH

INDUSTRIAL ENGINEERING – AGILE FACTORY MANAGEMENT
YEAR 1 - SPRING SEMESTER

LEAD PROFESSOR: Spencer Hawkridge- *spencer.hawkridge@ec-nantes.fr*

Objectives

Interview techniques and communicational English:

- Understand the general concepts of interactive communication
- Build a media project
- Acquire interview techniques
- Understand the process of sourcing and checking facts and figures
- Understand issues related to plagiarism
- Create a bibliography
- Behavioral skills in an inter-cultural environment:
- Strengthen self-confidence and capacity for interaction
- Develop active listening and reformulation skills
- Develop networking skills

Course contents

Cultural and Communicational English: exercises to explore in practice the areas of culture and communication.
Media project (for example: prepare, conduct and promote interviews for a radio programme: *L'Heure Centralienne* (http://www.euradionantes.eu/emission/l-heure-centralienne), with the contribution of professors, PhD students, industrial partners, industry players at fairs, etc.

Course material

Written and televised press, information and digital tools, general documents business environment and company strategies.
Internet conferences (Ted Talks, etc.), our own educational materials on Hippocampus (Moodle).
Our own eZoomBook template for the Intercultural project.

Keywords

Culture and communication, inter-cultural environment, team-building, digital tools, etc.

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	0 hrs	30 hrs	0 hrs	0 hrs	2 hrs