SYLLABUS

2019-2020

semester 8

CENTRALE MARSEILLE

Building blocks for life

Bio-engineering

Marc Jaeger
Head of theme at École centrale de Marseille

Crédits ECTS
6

Code de l'UE
ING_S8_BIO_BRI

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
74	0	4	0	0	0	**78**

Language
French

Team
– Karine Alvarez
– Anaïs Baudot
– Stéphane Betzi
– Stéphane Canaan
– Alexandre Martinez
– Marc Jaeger
– Jean-Marie Rossi
– Stéphane Bourgeois
– Serge Mesure

Objectives

The complexity of living matter is linked to its multiscale organisation; the object of this teaching unit is to present an overview of this topic through a multidisciplinary approach. By approaching the study of an object, a material, a system, with the vision of several disciplines, the advantages of multidisciplinary training for new scientific, technological and societal challenges are revealed.

Programme

The subject of this teaching unit is biological material from a multiscale perspective, from the nano-molecular and cellular scale right up to the human scale, passing through the mesoscopic scale of biofluid circulation and the macroscopic scale of tissues. It can be broken down into four parts:
- "basic building blocks", which describes living matter at the molecular and cellular scales;
- "soft matter and microfluidics", which, by integrating molecular organisation into a statistical thermodynamic approach, allows the mean-field, and finally, the continuous material medium to be described;
- "modelling tissues", which integrates structural tissue-related data at a microscopic scale up to the human scale, in a description of the biomechanics of continuous media;
- "anatomy and pathology", which describes the biomechanical functions and disfunctions of the human body.

The detailed teaching content is available in the online documentation on the school's Web site (in French and English)

Skills

The disciplines involved are chemistry, physics, and mechanics, as well as mathematical and numerical modelling. This course completes the other modules related to the structure of matter and its behaviour. Living matter is largely recognised today to be a promising source of inspiration for the fields generally referred to as "biomimetics" or "bio-inspired" materials.

Assessments

Continuous assessment

Bibliography

– B. Alberts, A.D. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts and P. Walter, Molecular Biology of the Cell, Garland Science, 2015
– J.N. Israelachvili, Intermolecular and interface forces, Academic press, 2011
– S.C. Cowin, Tissue mechanics, Springer, 2007
– A.I. Kapandji, Anatomie fonctionnelle, Maloine, 2018

Imaging and wave-based therapies

Bio-engineering

Gaëlle Georges
Head of theme at École centrale de Marseille

Crédits ECTS
5

Code de l'UE
ING_S8_BIO_IMA

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
51	0	17	0	0	0	**68**

Language
French

Team
– Gaëlle Georges
– Hervé Rigneault
– Carine Guivier-Curien
– Philippe Lasaygues
– Serge Mensah
– Salah Bourennane
– Caroline Fossati
– Thierry Gaidon

Objectives

Following this teaching unit, students will have a good knowledge of the bases and possibilities proposed by medical imaging (wave-matter interaction for data treatment). They will also gain a deeper understanding of the physiological properties and metabolic processes targeted by the various methods, and of the numerical techniques implemented, which are specific to each technique. This skill base will then allow them to meet diagnostic and therapeutic needs, while appreciating the medical constraints.

Programme

Medical imaging has raised multiple challenges. In the field of health, non-invasive observation of the body provides morphological, metabolic and functional information, leading to significant progress in terms of care and public health (screening). From an industrial point of view, the development of new techniques has led to the manufacture of increasingly sophisticated machinery providing greater specificity. Covering a broad dynamic range (from the cellular scale to the macroscopic scale), we will describe wave-tissue interactions and how they can be exploited for imaging and therapy. The various imaging methods, from the most conventional to the most advanced, and the associated therapies will be put into perspective. Treatment of digital images is a key step to help with diagnosis and therapeutic follow-up. In particular, the following will be addressed: the notion of image quality, data analysis, pursuing objects in sequences and with the help of decision-making approaches. The aim is to provide training on the most advanced imaging methods, taking the physical foundations into account so as to be able to propose the best potential innovation for medical applications. This teaching unit can be broken down into three parts:
- “cellular and subcellular microscopy”;
- “medical imaging and therapy”;
- “image treatment”.
The detailed teaching content is available in the online documentation on the school’s Web site (in French and English)

Skills

This course extends the basic concepts in physics, mechanics or image treatment to imaging and wave-based therapies (applied to living organisms). These techniques involve analysis of the information provided by interactions between waves and matter, so as to obtain an image and/or potentially therapeutically useful effect on the matter. Data treatment for diagnostic, reconstructive or follow-up needs will also be covered. Students will analyse the socio-economic context of medical imaging and therapy thanks to a presentation of the challenges associated with each technique. This facet of the course will allow them to measure the potential for innovation. Practical work will consolidate these different notions.

Assessments

Continuous assessment

Bibliography

– M. Locquin and M. Langeron, Handbook of Microscopy, Butterworth-Heinemann, 1983.
– V. Tuchin, Tissue optics: Light scattering methods and instruments for medical diagnosis, SPIE Press, 2015
– J. Beutel, R. Van Metter and H. Kundel, Handbook of Medical Imaging: Physics and Psychophysics, SPIE Press, 2000
– I.N. Bankman, Handbook of Medical Image Processing and Analysis, Academic Press, 2009

Biotechnologies and chemical therapies

Bio-engineering

Marc Jaeger
Head of theme at École centrale de Marseille

Crédits ECTS
5

Code de l'UE
ING_S8_BIO_PHA

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
59	0	9	0	0	0	**68**

Language
French

Team
– Karine Alvarez
– Stéphane Betzi
– Stéphane Canaan
– Philippe Roche
– Nelson Ibaseta
– Anaïs Baudot
– Léo Lopez
– Élisabeth Remy
– Alexandre Martinez

Objectives

Drug development is a multi-parameter process which includes regulatory, temporal and societal constraints alongside an element of innovation. In addition, complex specifications must be integrated (efficacy, availability, safety, etc.). It is thus the epitome of a field in which solutions emerge thanks to a capacity to exercise complementary skills and address multiparametric problems. Study of the development and life cycle of a pharmaceutical compound illustrates the multidisciplinary aspects of this field, and demonstrates the advantages of general training to deal with new scientific, technological and societal challenges.

Programme

The core of this teaching unit relates to the creation and market release of new active ingredients and biotechnological devices. The aim is to stimulate students' capacity to invent creative, ingenious, novel solutions inspired by previous solutions and current developments. In addition, a large part of the course is devoted to bio-informatics and biotechnology, aiming to use genomes, biomolecules, cells and tissues to create innovative devices to meet future human challenges. This teaching unit can thus be broken down into four parts:
– "molecular therapy strategy";
– "pharmaceutical procedures";
- "bioinformatics";
– "inorganic biochemistry and bio-inspired chemistry".
The detailed teaching content is available in the online documentation on the school's Web site (in French and English)

Skills

This teaching unit calls on knowledge in chemical engineering and chemistry for pharmaceutical aspects and for the bio-inorganic study of living systems as part of a biomimetic chemistry approach. Students will also use discreet mathematics and basic computing skills for bioinformatics aspects. The knowledge provided completes that already acquired in these disciplines, and is useful in itself. The field will stimulate students' imaginations, thanks to its direct links to the life sciences, which – thanks to its multi-million-year evolutionary creativity – is the richest source of inspiration for humans.

Assessments

Continuous assessment

Bibliography

– Ng. Rick, Drugs: from discovery to approval, Wiley-Liss, 2004
– J.W. Mullin, Crystallization, Butterworth Heineman, 2001
– 0. Papini and H. Prade, L'intelligence artificielle: frontières et applications, Cépaduès, 2014
– J.E. Huhey, E.A. Keiter and R.L. Keiter, Inorganic Chemistry, De Boeck, 2004

Planet BIO

Bio-engineering

Marc Jaeger
Head of theme at École centrale de Marseille

Crédits ECTS
5

Code de l'UE
ING_S8_BIO_BIO

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
26	0	0	0	20	0	**46**

Language
French

Team
– Gaëlle Georges
– Marc Jaeger
– Jean-Marie Rossi

Objectives

The objective of this teaching unit is to present the socio-economic sector, by offering students the possibility to interact with their future professional environment. It is thus placed outside the limits of normal academic training. The aim is to allow students to emerge from the framework of the School and to familiarise themselves with the sector. S8 Bio-engineering provides a very broad perspective, ranging from meeting the biological and health community from Aix-Marseille to, potentially, completing a project.

Programme

Bio-engineering is the ideal example of a rapidly expanding emerging activity sector; its growth is continuously fed by scientific and technological discoveries produced by public and private research laboratories. With an exceptional group of researchers and clinical practitioners, and a range of laboratories allowing us to cover a very large research spectrum in bio-engineering, the Aix-Marseille site provides a great opportunity to understand the challenges in this sector, for those who are willing to leave the school's bounds.
The detailed teaching content is available in the online documentation on the school's Web site (in French and English)

Skills

The mode of assessment is also novel. It relates, in particular, to the student's behaviour, assessed based on their commitment to the proposed activities and the attitude adopted during meetings in the professional environment. It also involves production of an audio-visual report lasting a few minutes (clip), a skill which is increasingly in demand today. Specific training will be provided for this aspect at the start of the semester.

Assessments

Continuous assessment, video clip

Bibliography

N.A.

Beyond the model

Dynamics - Mutations - Crises

Alain Kilidjian
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_DMC_DELA

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
15	5	10				**30**

Language
French

Team
– Alain Kilidjian
– Mathematics lecturer

Objectives

- Students will come to understand and analyse the inherent limitations of each model
- Be capable of identifying situations where a model no longer seems appropriate
- Know how to analyse and control a complex system without recourse to a model

At a more general level, this TU aims to provide students with the skills and knowledge necessary to be aware of the limitations of models of complex systems.

Programme

Modelling a trend and detection of a break-point (10 h: 5-3-2-0)
This short course provides some tools to model trends in numerous data series available in the fields of application of S8. The engineering student will discover that a model may need to evolve (or be revised). The earlier this regime change is detected, the better the adaptation. To achieve this, a few tools will be presented to assess changes to the model (multiple regression, break-point detection, hidden Markov chain). In this module, we will study various applications in climatology/meteorology, economics/finance and biology.

Fuzzy command (16 h: 6-2-8-0)
The approach to modelling and its use to control a system can be difficult to implement if the system is overly complex: it is thus necessary to present an alternative approach, and, possibly, to compare the two. Based on the sample applications planned for S8, we propose an approach based on fuzzy logic (absence of a model of the complex system) to control the behaviour of a complex system.

Limitations of modelling. Scientific and technical, philosophical, cultural and political aspects (4 h: 4-0-0-0)
This module aims to demonstrate - from several multidisciplinary standpoints - the limitations of modelling and the necessarily partial nature of any model. This module is designed in the form of conferences given by speakers from outside the School. Its precise content will thus depend on the speakers invited.

Skills

- Students will acquire the capacity to develop creative, ingenious, novel solutions
- The capacity to draw on general scientific/technical knowledge (transdisciplinary and/or specialisation)
- The capacity to understand and formalise a problem (hypotheses, orders of magnitude, etc.)
- The capacity to propose one or more potential solutions

Assessments

– CA1: Modelling trends (assignment) 40%
– CA2: Fuzzy commands (write-up) 30%
– CA3: Fuzzy commands (programme) 30%

Bibliography

Course notes - documents depending on the lecturer

Crisis management: physical and chemical applications

Dynamics - Mutations - Crises

Frédéric Schwander
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_DMC_CRIS

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
13	18			9		**40**

Language
French

Team
– Nelson Ibaseta (section 2)
– Philippe Réfrégier (section 1)

Objectives

- Students will learn when and how to use the techniques and science of randomness, statistics and complexity. They will illustrate these ideas using applications of various natures
- Expand their thinking, obtain a certain level of knowledge of information, physical and chemical sciences which will allow them to tackle the problems encountered
- Establish links with the associated mathematical tools
- Develop their desire to play an active role in the field
- Develop a holistic view

Programme

Section 1: Information, complexity and statistical risk (10-8-0-6)
- Review of probability and classical statistical theory
- Theory of statistical risk for decision-making or estimation
- Elements of information theory
- Elements of Kolmogorov complexity
- Inferring probability laws and principle of maximum entropy
- Stochastic complexity and application to the estimation of order in a model
- Sample applications in physics

Section 2: Non-linear chemical phenomena (3-10-0-3)
A large number of chemical reactions are governed by non-linear kinetics. This can result in unexpected phenomena, such as oscillating reactions, and sometimes dangerous phenomena, such as runaway chemical reactions, which could lead to reactor explosions.

These phenomena will be addressed in this course through examples. Their type and the challenges they present will first be introduced, then we will characterise them based on a few carefully selected cases.

Skills

Ecole Centrale engineers can control the complexity of the systems and issues they encounter.

Assessments

– CA1: Write-up on section 1, 70%
– CA2: Write-up on section 2, 30%

Bibliography

- Course notes - depending on the lecturer

Dynamic instability and chaotic transport

Dynamics - Mutations - Crises

Frédéric Schwander
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_DMC_INST

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
9	6	22	0	0	0	**37**

Language
French

Team
– Guido Ciraolo
– Bruno Cochelin
– Emmanuelle Sarrouy
– Frédéric Schwander

Objectives

- Students will learn how to apply the notions addressed in the "Mathematical modelling of complex systems" course to examples of dynamic systems involving fluid and solid mechanics
- Become familiar with the concept of instability, and be able to identify its emergence based on several applications
- Become familiar with the properties of a Hamiltonian system, identify critical points in the phase space, identify deterministic chaos in a Hamiltonian system, learn about transport in a chaotic system

Programme

Starting from the general equations describing the mechanics of continuous media (MCM, 1st year), we will establish the equations of motion for the system considered, and discretised in spaces to return to a dynamic system, generally of small size. The instabilities and their consequences will be described using the basic notions covered by the "Mathematical modelling" of complex systems course.

A few examples of the mechanics of solids (15 h)
- Collapse of a structure by buckling
- Screeching of a brake or clutch pad
- Self-oscillation in musical instruments (bowed string instruments, woodwinds, brass instruments)
- Aeroelastic instability of an airplane wing or bridge; instability of a grounded helicopter

We will study the behaviour of and transport phenomena in a chaotic Hamiltonian system. The notion of transport will be illustrated through digital applications exploiting the analogy between Hamiltonian systems and incompressible fluids.

A few examples from fluid mechanics (22 h)
- Fusion plasmas (dynamics and chaos in magnetic lines, particle diffusion by ExB drift)
- Neutral liquids: dynamics and mixing in liquids

Skills

Mastery of complexity and systems
The TU allows students to develop the theoretical tools necessary to understand instability in chaotic systems. It contributes to students' capacity to address the diversity of behaviour in a dynamic system, providing them with the tools to describe this behaviour through mechanics-derived applications.

Assessments

– CA1: Dynamic instabilities in continuous media (Practical), 40%
– CA2: Chaotic transport and control strategies: applications to fluids (Practical), 30%
– SE1: Chaotic transport, 30%

Bibliography

Course notes.

Mathematical and statistical modelling of complex systems

Dynamics - Mutations - Crises

Christophe Pouet
Head of theme at École centrale de Marseille

Crédits ECTS
6

Code de l'UE
ING_S8_DMC_MOMS

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
30	20	25				**75**

Language
French

Team
– Guillaume Chiavassa
– Jacques Liandrat
– Malek Abid

Objectives

- Students will become familiar with the theory of dynamic systems in discrete and continuous time
- Become familiar with the theory of stability
- Become familiar with the theory of differential equations
- Become familiar with the theory of estimation and detection for extreme phenomena
- Learn how to choose the appropriate tools to model a phenomenon
- Learn how to implement a model with parameter evaluation and to illustrate various behaviours using simulations
- Learn how to use or develop appropriate numerical methods to solve a problem efficiently
- Master the computing tools necessary for the implementation of numerical models

Programme

Mathematical modelling of complex systems I and II (30 h: 9-7-14-0)
Discrete models, continuous dynamic systems, associated numerical methods; equations with partial derivatives, numerical methods and examples of applications in biology

The Lorenz system: a simple meteorology model (15 h: 10-5-0-0)
General introduction (meteorology, Lorenz's discovery, Rayleigh-Bénard convection and the Lorenz system); Rayleigh-Bénard instability (theory of linear stability; fundamental equations and Boussinesq approximation; basic flow and linearisation of equations; dimensionless equations: Rayleigh and Prandtl numbers; transition between conduction and convection); chaos (notion of attractors and sensitivity to initial conditions; study of the Lorenz system. Numerical simulations of the Lorenz system)

Extreme values (15 h: 6-6-3-0)
Extreme values, order statistics, fields of attraction in a distribution of extreme values, Hill estimator, Pickands estimator, distribution tails, behaviour of excess elements, Pareto's law, Gumbel's law, Weibull's law. Use of R and Matlab software

Detection of anomalies (15 h: 5-2-8-0)

Skills

Ecole Centrale engineers can control the complexity of the systems and issues they encounter.

Assessments

SE1: Dynamic systems 20%
CA1: Dynamic systems (assignments) 12%
CA2: Dynamic systems (Practical) 8%
SE2: Lorenz model 14%
CA3: Lorenz model (Practical) 6%
CA4: Extreme values (questions) 20%
CA5: Detection of anomalies (Practical) 20%

Bibliography

Course notes in English

Economic and financial models: the need for regulation

Dynamics - Mutations - Crises

Frédéric Schwander
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_DMC_MODF

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
36	4					**40**

Language
French

Team
– Nicolas Clootens
– Nicolas Abad

Objectives

Part I: Economy of the environment and environmental resources
This course proposes an introduction to the issues related to environmental economics and natural resources. By exploiting the dynamic optimisation tools studied in other courses covered during the academic trajectory, we will cover a set of common issues in the field: mine management issues, predator-prey models, fisheries models. In addition, a more "static" part of the course will investigate the need for regulation (and the available tools) to correct external factors.

Part II: Economic growth and crises
This course aims to present students with the main factors explaining a country's long-term economic growth. These factors will be presented through empirical evidence and stylised facts, which establish the elements of reflection used during theoretical modelling of economic growth.

Programme

Part I: The resource economy
I. Introduction
II. Optimal management of a non-renewable supply of resources
III. Population models
IV. Dynamics of fisheries
V. Needs and instruments for environmental policies
VI. Management of a stock pollutant, theoretical and numerical analysis

Part II: Economic growth and crises
I. Introduction: empirical regularity and stylistic facets of economic growth
II. Exogenous growth models
III. Introduction to models

Skills

The main generic skills of Ecole Central engineers developed during this teaching are C2, C3 and C5.
The course topic, and more generally the academic trajectory, relates to skill C2.
Reflection on economic theory contributes to skill C5.
Finally, skill C3 is developed by the method used to assess the TU.

Assessments

CA: homework 100%
Assessment of the TU is based on a group project. Part of the project is an assignment summarising the two courses on which the TU is based. The second part of the project asks students to pursue their assignment by developing a mini-research project.

Mathematical optimisation and application to control

Dynamics - Mutations - Crises

Guillaume Graton
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_DMC_OPTI

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
14	10	14				**38**

Language
French

Team
– Guillaume Graton
– Samia Mellah
– Taki-Eddine Korabi
– Youssef Trardi

Objectives

Mathematical optimisation methods are applied in a large number of fields linked to engineering, whether simply as numerical analysis tools or dynamically, such as to deal with optimal command problems.

The objective of this course is to present the theoretical aspects of unconstrained static optimisation, then those of constrained optimisation (Lagrangian, KKT, saddle points and duality), as well as the main optimisation algorithms (gradient, conjugated gradient, Newton's method, quasi-Newton method, etc.). The stochastic aspects of optimisation will be addressed using simulated annealing and cross entropy.
This first part aims to introduce the notions of static optimisation, with a view to extending them to dynamic optimisation and to optimal control problems in the second part. The latter will be dedicated to Hamilton's equation, Pontryagin's minimum principle, and Bellman's optimality principle. This will lead to Riccati's equation and to solving differential algebraic equations. Various examples will be used as illustrations.

Programme

The course can be broken down into two parts:
Part I relates to static optimisation, during which students will acquire the following notions:
- mathematical foundations, definition and selection of criteria, unconstrained optimisation, definitions of constraints and constrained optimisation, algorithms / numerical methods, stochastic aspects, towards identification.

Part II relates to dynamic optimisation and optimal control; students will acquire the following notions:
- choosing the criterion, dynamic constraints, Hamilton's equations, Pontryagin's principle of optimality, dynamic programming and Bellman's optimality, Riccati's equation, towards optimal control.

Skills

The continuous assessment will assess the following skills:
– C1 Theme 1: intermediate level
– C1 Theme 2: beginner/intermediate level

The exam and continuous assessment will assess the following skills:
– C2 Theme 1: competent level
– C2 Theme 2: intermediate level

Assessments

The knowledge acquired will be assessed in two different ways:
– 66% 2-h written exam without access to documents, calculator allowed
– 34% write-up of the two Practical sessions (static optimisation and dynamic optimisation)

Bibliography

– G. Allaire and S.M. Kaber, Algèbre linéaire numérique, Ellipses, 2002
– P.G. Ciarlet, Introduction à l'analyse numérique matricielle et à l'optimisation, Dunod, 1998
– M. Bergounioux, Optimisation et contrôle des systèmes linéaires, Dunod, 2001
– B. d'Andréa-Novel and M. Cohen de Lara, Cours d'automatique, commande linéaire des systèmes dynamiques, École des Mines de Paris, 2000

Sustainable chemistry

Environment: management and technology

Damien Herault
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_EDD_CHDU

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
28	6	8				**42**

Language
French

Team
– D. Hérault (ECM)
– External presenters

Objectives

Sustainable chemistry relates to the industry of matter-transforming procedures. This module provides the essential bases of green chemistry and processes, and allows students to understand the potential for recycling and industrial symbioses, which are presented in the "Circular economy" TU. It is thus a question of discovering and appropriating methods based on the development of the associated innovative and clean chemical technologies, focusing on the use of biosourced materials and on the desire to implement clean processes (less polluting and/or requiring fewer raw materials or less energy). The sustainable chemistry course is inspired by the European chemical regulations, REACH, and the notions of eco-design-based principles and the circular economy, which are directly linked to sustainable chemistry.

Programme

The programme of the TU addresses the aspects of sustainability, the 12 principles of green chemistry, catalysis in homogeneous and heterogeneous phases, biocatalysis, new reaction media, renewable raw materials, and novel concepts guiding research and development in the field (such as biomimetism).
More precisely, the TU is centred around the following themes:
– introduction to green chemistry, towards a biosourced economy?
– health and environmental safety: REACH, new European chemical regulations
– agroresources
– reducing quantities of materials. Alternative solvents
– catalysis (organocatalysis / biocatalysis / homogeneous catalysis)
– practical work
– green processes: cells considered as living factories, energy concentration and saving

Skills

– C1: Scientific and technical innovation
– Development of new, more economical and/or more effective processes, based on extensive knowledge of basic principles
– C2: Mastery of complexity and systems
– Better management of the production pipeline, use of resources, waste treatment, the circular economy

Assessments

– Green chemistry: assessment, 25%
– Green chemistry: continuous assessment, 25%
– Green chemistry: practicals, 30%
– Green processes: continuous assessment, 20%

Bibliography

– S. Antoniotti, Chimie vert Chimie durable, Ellipses Marketing (2013)
– J. Augé and M.-C. Scherrmann, Chimie verte: Concepts et applications, EDP Sciences/CNRS (2016)

Circular economy

Environment: management and technology

Christian Jalain
Head of theme at École centrale de Marseille

Crédits ECTS
4

Code de l'UE
ING_S8_EDD_ECCI

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
25	12	12		4		**53**

Language
French

Team
C. Jalain (ECM)
External presenters

Objectives

The TU relies on sustainable chemistry (technological tools) and environmental management (managerial tools), it provides ecodesign tools, which taken together can be used to transform waste into new resources, and beyond, to develop industrial ecology, a veritable emerging trend in economics circles.
This TU trains ECM engineers in transversal skills. The various disciplines involved are chemical engineering, industrial engineering and chemistry; methods for life cycle analysis (LCA), which have been considerably developed in the last few years, are also included.
The main objective of the TU is to help students to understand the environmental, societal and economic stakes for industries transforming resources into products.

Programme

- Discover the ADEME's "carbon footprint" tool, to assess a company's or site's greenhouse gas emissions (GGE), and the tool to help define a strategy in terms of energy management with a view to reducing energy costs
- Get to know the multicriterion, multi-stage structure of an ecodesign approach (in line with the eponymous French standard) and the stringent constraints added when the environment is considered in standard technico-economic design
- Discover the ASIT method, which is an applied and easily understood adaptation of the TRIZ principles recently developed by Roni Horowitz
- Become familiar with the standardised "life cycle analysis" assessment method to measure the impact of an industrial system on its environment
- One of the major challenges for the transformation of industry for the 21st century is to shift from a resource-product-waste transformation pipeline to processes where waste is considered a new resource
- In the "reclamation" part, an overall approach to processes for matter transformation will help students to understand how different pipelines interact, and provides elements for selection of the recycling or reclamation processes to be applied to effluents or waste. Industrial examples of waste reclamation provide opportunities for sustainable chemistry and industrial ecology.

Skills

– C1: Scientific and technical innovation
In combination with the teaching in the other TU for this S8 trajectory, students will learn how to establish a diagnosis which they will then use to suggest manufacturing or waste reclamation/treatment processes to develop a more virtuous product cycle as part of the advance towards a circular economy (C1)
– C2: Mastery of complexity and systems:
- Students will master the methods to assess the environmental impact of a process or manufacturing or design pipeline (C2)
- Learn how to interpret the results of such analyses and identify the steps or procedures where significant improvements can be made (C2)
- Learn how to model and analyse a process or manufacturing or design pipeline (C2)

Assessments

– Ecodesign: continuous assessment, 30%
– Life-cycle analysis: continuous assessment, 30%
– Industrial symbioses: project performed in pairs, 40%

Bibliography

Several articles in the Revue des Techniques de l'Ingénieur

Effluents and pollution

Environment: management and technology

Audrey Soric
Head of theme at École centrale de Marseille

Crédits ECTS
4

Code de l'UE
ING_S8_ENV_EFP0

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
26	14	4		2		**46**

Language
French

Team
– A. Soric
– P. Guichardon
– N. Ibaseta
– F. Anselmet (ECM)
– External presenters from private companies

Objectives

The TU relates to treatment of effluent and modelling its dissemination in the environment. It is strongly linked to the TU on monitoring (detecting and measuring pollution) and the TU on the circular economy (waste reclamation). The objective of this TU is to give students a broad view of the techniques available to treat effluents - in particular waste water, with a view to reusing a proportion of it if possible - and methods to monitor river pollution.
monitorin
In detail, the TU is organised around the following themes:

- Effluent treatment: (33 h)
Water treatment
Membranes
Phytotechnology: soils and water
Excursion to visit a site (STEP Marseille)

– Dissemination in the environment: (13 h)
Modelling the dispersion of pollutants in rivers
Transfer of radionuclides to river waters

Programme

Following an introduction on water (resources, requirements, quality and main pollutants), the classical pipeline for waste-water treatment will be presented. We will then particularly focus on the following single operations: decantation, coagulation - floculation, filtration, and barometric membrane separation.

The second part of the course starts with lectures and exercises presenting the main characteristics of river or canal flow, as well as the various issues linked to the erodable or stable properties of solid grains (in particular sediments) which constitute the depths and banks. These elements of theoretical modelling are based on methods used in numerical models of transfer/dispersion of radionuclides in rivers, which will be presented in the form of a case study, the proportion linked to the sedimentary dynamics plays a major role for this type of pollutant, which largely bind to sediments measuring less than 50 microns.

Skills

– C1: Scientific and technical innovation
- Development of new, more economical and/or more effective processes, based on extensive knowledge of the basic principles
– C2: Mastery of complexity and systems
- Better management of the waste production/treatment chain, to get as close as possible to sustainable development objectives and, if possible, reclamation of waste water (process linked to the circular economy).

Assessments

– Treating waste water: 2-h assessment (50%)
– Chemical engineering practicals: practicals (20%)
– Modelling (rivers): 90-min assessment (30%)

Bibliography

Several articles in the Revue des Techniques de l'Ingénieur

Environmental management

Environment: management and technology

Fabien Anselmet
Head of theme at École centrale de Marseille

Crédits ECTS
4

Code de l'UE
ING_S8_EDD_MENV

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
32	6	8				**46**

Language
French

Team
– J. Gazérian (ECM)
– External presenters

Objectives

Environmental management is part of a sustainable development perspective. The TU integrates the technical, regulatory, behavioural and economic components at company level and establishes the role and missions of an engineer. It is strongly linked to the TU on the circular economy. For the regulatory aspects, we are particularly interested in corporate social (or societal) responsibility (CSR) and the ISO 14000 standard, which are the cornerstones of environmental management. Economic challenges are addressed from the point of view of economic science applied to the environmental economy and sustainable development (e.g. to analyse economic mechanisms, understand how a company can adapt when faced with a scarcity of resources, predict outcomes, etc.).

Programme

The part of the course dealing with management and the regulations aims to help students understand and include environmental considerations in their daily practice. This attitude is essential for any company leader, who must consider technical, regulatory, behavioural and economic aspects. The objective is for students to be able to rank the main environmental challenges for a company, to establish environmental strategies and perform environmental audits. This goal will help to develop, implement and improve environmental management systems.
The part of the TU relating to environmental economics focuses on five main points: introduction to environmental economics; integration of environmental challenges in decision-making; assessing public policies, setting up indicators and sensitising consumers to environmental issues; study of sustainable development reports; and presentation of this work. This group work allows students to study the sustainable development policy of a few large French companies, with a 15-min oral summary presentation during lectures and a written report to be handed in at the last lecture.

Skills

– C1: Scientific and technical innovation
– C2: Mastery of complexity and systems
– C3: Programme direction
– C5: Strategic vision
– Students will learn how to perform an analysis or diagnosis of a company with regard to environmental management problems (C1 + C2 + C3 + C5)
– Become aware of and familiar with the main regulatory constraints linked to environmental management (C1 + C2 + C3 + C5)

Assessments

Written assessment (2 h) 100%

Bibliography

– M.-P. Grevêche and L. Vaute, Au cœur de l'ISO 14001:2015: Le système de management environnemental au centre de la stratégie, AFNOR (2015)
– L. Abdelmalki and P. Mundler, Économie de l'environnement et du développement durable, De Boeck (2015)
– T. Tietenberg et coll., Économie de l'environnement et du développement durable, PEARSON (2013)
– Articles in the Revue des Techniques de l'Ingénieur

Project

Environment: management and technology

Fabien Anselmet
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_EDD_PROJ

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
				30		**30**

Language
French

Team
- ECM teachers
- External supervisors (from private industry or other)

Objectives

– Students will learn to exploit the various sources of knowledge and skills learned during their training, whether technical or organisational
– To address a real problem and its various constraints
– To obtain the necessary additional knowledge and skills for a project
– To find this information beyond the circle usually implemented in the School
– To work as a team in interaction with a project initiator
– To structure their work over time

Programme

– Various topics are proposed at the start of the semester (early or mid-March) and each one is dealt with by a group of two or three students. These topics are points of interest for academic (and/or industrial) research and industry.
– Projects are supervised by one or two teachers or external collaborators.
– One half-day per fortnight is dedicated to this project (30 h in all).
– At the end of the project, students make an oral presentation and produce a written report.

A few examples of topics from previous years are:
– Fumes from ships in Marseille port (ECM teacher)
– Green solvent (ECM teacher)
– Propose a subject for a 1st year open day linked to sustainable development (ECM teacher)
– Mosquitos: study of the toxicity of antimosquito devices (Techno-Beam)
– Remediating polluted soils (Novachim)
– Study of sources of industrial plastic and metallic packaging (Novachim)
– Environmental optimisation of HAU filtering (Oleo-déclic)
– Harvesting atmospheric humidity using "mist-capturing" nets (UTEC, Lima)
– Storage and reprocessing of earth produced during major excavation work (Geosafe)

Skills

– Students will learn how to address and break down a complex problem (C2)
– How to propose innovative, but realistic solutions (C1)
– How to distribute tasks to be performed in line with the desires or skills of each member of the group (C3)
– How to structure their work over time (C3)
– How to report on their work (C3)
– How to organise a group and interact with external collaborators (C4)

Assessments

- Final report: 0.4
– Oral presentation: 0.4
– Work performed: 0.2
(supervisor's opinion)

Bibliography

- Subject-related S8 courses and any other document available at the documentation centre or online (in particular, engineering techniques)
- Courses from other semesters on project management and general management (as necessary, to review the important points)

Monitoring environmental quality

Environment: management and technology

Mireille Guillaume
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_ENV_SQEN

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
20	12	12			2	**46**

Language
French

Team
– Jean Bittebierre and D. Nuel: 6 h Lectures, 4 h Tutorial, 2 h Practical
– F. Anselmet: 2 h visit
– C. Maury and D. Mazzoni: 2 h Lectures, 4 h Tutorial, 2 h Practical
– A. Roueff: 4 h Lectures, 4 h Practical
– R. Marion (CEA): 2 h Lectures, 4 h Practical
– External presenters (CEA, LMA/CNRS, Atmo Sud): 6 h Lectures, 4 h Tutorial

Objectives

The TU groups together tools to measure the quality of water, the atmosphere and the sound environment. Based on environmental management (standards, territorial monitoring), effluents and specific pollution (treatment of effluents and pollution, and modelling the diffusion of pollution), the objective is to provide future engineers with the methods and tools for geomonitoring (in a natural and urban setting) and detection of pollutants, whatever the scale of the analysis. These tools will allow them to understand / develop the whole environmental monitoring chain, which extends from data acquisition using dedicated sensors to data treatment, and includes modelling of physical phenomena. The monitoring fields dealt with range from chemical atmospheric pollution to the prediction and reduction of noise levels in urban settings, while also covering the state of continental surfaces (vegetation) by imaging.

Programme

This TU presents the tools used to detect pollution indicators, at a local and global scale, based on environmental sensors and measurements, and geomonitoring. It also covers issues related to environmental noise pollution, so as to improve the sound environment (linked to the notion of the sustainable silent town).

1. Environmental sensors and measurements (J. Bittebierre and D. Nuel)
Localised measurements using independent or networked sensors to allow precise follow-up, in real-time, of closed sites or wider areas. Emphasis is placed on the sensors most commonly used for localised precision measurements, and on the components used to collect imaging data (optical sensors, including LIDAR [optical monitoring radars based on laser] and hyperspectral cameras [camera providing the spectral composition of each point on an image], chemical sensors and gas sensors).

2. Remote sensing (R. Marion and A. Roueff)
Remote sensing methods for geomonitoring and characterisation of pollution. Relevant information can be extracted relating to the state of vegetation, soils and seas from embedded imaging sensors (multi-spectral or radar). We will see how remote sensing works and how to implement algorithms for mapping through several sample applications.

3. Noise pollution (C. Maury and D. Mazzoni)
We will investigate outdoor or indoor noise pollution, relying in particular on characterisation of an acoustic field and sources, and applying data treatment with the help of acoustic screens. A conference will present the acoustic technique and its application in the prevention of risks associated with CO2 storage.

Skills

– C1: Scientific and technical innovation
-> Students will be capable of following the development (in particular at the level of automated data treatment) of new or more powerful methods (C1)
-> They will be capable of supervising the implementation of a monitoring technique in a new context (C1)
– C2: Mastery of complexity and systems:
-> Students will learn how to analyse a pollution-related problem (C2)
-> They will master experimental methods for use in these types of situation to propose an appropriate monitoring method implementing the most relevant detection and monitoring techniques (C2)
-> They will learn how to interpret experimental results, and identify problematic situations (failures, abnormal background noise, various disfunctions) (C2)

Assessments

– CA1 ("Teledetection" part): average grade for write-ups - Proportion of final grade = 40%
– CA1 ("Sensors" part): presentation + bonus for Tutorial - Proportion of final grade = 30%
– CA1 ("Acoustics" part): written project report - Proportion of final grade = 30%

Bibliography

– Georges Asch et coll., Les capteurs en instrumentation industrielle, 5th édition, Dunod, 1999
– Frédéric P. Miller, Acoustique environnementale, Alphascript Publishing, 2010
– Several articles in the Revue des Techniques de l'Ingénieur

Which alternative energies for tomorrow? Examples of biomass and hydrogen

Sustainable energy

Fabien Anselmet
Head of theme at École centrale de Marseille

Crédits ECTS
2

Code de l'UE
ING_S8_ENE_BIHY

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
18	12					**30**

Language
French

Team
– Fabien Anselmet
– Pascal Denis

Objectives

This course will allow students to clearly identify, understand and master the stakes and challenges to be considered if technologies involving biomass and hydrogen are to be used by the general public.

Programme

The course deals with bioenergy, hydrogen and fuel cells in equal proportions. In addition, four hours are reserved to the study of geothermal energy. For bioenergy sources, an introductory session sets out the problem and stakes. Other sessions are focused on case studies and supervised personal work on specific points is linked, in particular, to ethanol (overall analysis of the process, pre-treatment, distillation processes, associated energy mix, etc.). For the part related to hydrogen and fuel cells, course sessions combine lectures and exercise/tutorial sessions. In particular, we will present the underlying thermodynamic aspects of redox reactions to allow students to fully understand how batteries function and the technological challenges involved in their optimisation. Aspects related to safety and emerging standardisation for these systems will also be presented, as well as examples of existing installations and systems in the fields of transport and stationary applications.

Skills

C1: Ecole Centrale engineers create value through scientific and technical innovation
C2: Ecole Centrale engineers master the complexity of the systems and issues they encounter.
C3: Ecole Centrale engineers conduct programmes.
C4: Ecole Centrale engineers apply ethical and responsible management techniques.

Assessments

SE + CA

Bibliography

A.V. da Rosa, Fundamentals of Renewable Energy Processes, Academic Press, 2012

Nuclear power

Sustainable energy

Frédéric Schwander
Head of theme at École centrale de Marseille

Crédits ECTS
4

Code de l'UE
ING_S8_ENE_ENUC

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
30	10	20				**60**

Language
French

Team
Y. Pontillon
J.C. Klein
C. Grisolia
F. Schwander
G. Ciraolo

Objectives

This course provides elements to allow students to fully understand the nuclear industry, its role in current and future energy production, its strengths and weaknesses, considering the various associated scientific, technological, environmental and societal aspects.

Programme

– Introduction: nuclear physics, fission reactions, fusion reactions

Fission module:
– Architecture and functioning of PWR and FNR nuclear reactors (J.C. Klein)
– Basic principles of nuclear systems (J.C. Klein)
– Fuel for nuclear reactors (Y. Pontillon)
– Review of the three major nuclear accidents: TMI, Chernobyl and Fukushima – what can be learned for nuclear safety? (Y. Pontillon)
– Nuclear safety (J.C. Klein)

Fusion module:
– Introduction to controlled fusion (C. Grisolia)
– Physics of nuclear fusion and quantifying reactor yield (C. Grisolia)
– Physics of plasma and magnetic confinement (F. Schwander)
– Scaling rules for the design of a fusion reactor (F. Schwander)
– Physics of the plasma/wall interaction (G. Ciraolo)
– Current status of fusion research - objectives and challenges for ITER (G. Ciraolo)

Skills

C1: Ecole Centrale engineers create value through scientific and technical innovation
C2: Ecole Centrale engineers master the complexity of the systems and issues they encounter.
C3: Ecole Centrale engineers conduct programmes.
C4: Ecole Centrale engineers apply ethical and responsible management techniques.

Assessments

Supervised exercises

Bibliography

Solar power

Sustainable energy

Laetitia Abel-Tiberini
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_ENE_ESOL

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
36						**36**

Language
French

Team
– Laetitia Abel-Tiberini
– Jean Bittebière
– Daniel Roux

Objectives

Among available sustainable energy solutions, solar energy is very abundant and perfectly renewable. This resource can be directly used in the form of heat (solar heating) or transformed into electricity (thermal power stations or direct transformation by photovoltaics). Due to its abundance, the proportion of solar energy is increasing in worldwide resources. During this TU we will study the characteristics of solar energy and the associated technologies to provide students with all the necessary tools to scale installations and understand current socio-economic and scientific challenges.

This TU is at the interface between several disciplines: electronics, optics, optronics, physics, thermic.

Programme

General introduction:
Societal challenges
Economic and technical problems, challenges
Solar potential: physical aspects
Principle of function of solar power, atmospheric absorption and local, temporal and spectral dependency of illumination. Qualitative study, followed by quantitative study using photometry.
Optimising illumination: solar concentrators. Energy balance (received solar energy, heat radiation, greenhouse effect)
*Science and technology of solar energy sensors:
**Photovoltaic sensors:
- Working principle: scaling a photovoltaic installation, semi-conductor, diode and photovoltaic effect; cells, cell matrices, impedance adaptation, challenges to be tackled (costs, yield, storage)
- Technological branches: silicon cells: mono and polycrystalline, amorphous; thin mineral layer cells: silicon, Cd In Si, Cd In Ge Si, CZTS
- Organic and hybrid thin layer cells
- Advanced concepts: surface structures, photonic crystals, plasmonics, quantum structures, concentration, etc.
- Conclusion and perspectives on photovoltaics: what is the potential, what will future uses be?

**Thermal solar sensors:
- Sensor design: structure, function, performance, test standards
- Sensors in a vacuum
- Other sensors (windowless sensors, concentration sensors, etc.)

**Scaling thermal installations:
- Applications of solar energy for domestic use
- Positioning (needs/provisions)
- Main components (sensors, storage, emitters, regulation)
- Calculating the rate of coverage (case of ECS and heating)
- Technico-economic optimisation elements

**Critical socio-economic analysis and conclusion:
- Solar potential, lifetime and yield of installations (needs, economics)
- Uses (local, diffuse, in a network)
- Energy independence
- Environment

Skills

C1: Ecole Centrale engineers create value through scientific and technical innovation
C2: Ecole Centrale engineers master the complexity of the systems and issues they encounter.
C3: Ecole Centrale engineers conduct programmes.
C4: Ecole Centrale engineers apply ethical and responsible management techniques.

Assessments

SE

Bibliography

A.V. da Rosa, Fundamentals of Renewable Energy Processes, Academic Press, 2012

Marine, wind and hydraulic energies

Sustainable energy

Fabien Anselmet
Head of theme at École centrale de Marseille

Crédits ECTS
4

Code de l'UE
ING_S8_ENE_EMEH

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
50						**50**

Language
French

Team
– Fabien Anselmet
– Michel Benoit
– Mohamed Boussak

Objectives

This course will allow students to clearly identify, understand and control the challenges and criteria to scale and optimise technologies and devices involving marine, wind and hydraulic energy.

Programme

The course is broadly split into three parts: marine energy (wave, tidal stream generators, etc.), hydraulic/hydroelectric energy, and wind energy. For each of these three parts, sessions combine lectures (which set the theoretical framework and physical laws underlying the functioning of the various devices) and exercises/tutorials (which allow students to design and scale installations). Among the concepts to be considered, specific criteria for scaling are presented, they are linked to coupling between mechanical devices and electrical systems. In addition, the target or required power range (which can range from a few Watts to several Giga Watts) will influence the technology selected.

Skills

C1: Ecole Centrale engineers create value through scientific and technical innovation
C2: Ecole Centrale engineers master the complexity of the systems and issues they encounter.
C3: Ecole Centrale engineers conduct programmes.
C4: Ecole Centrale engineers apply ethical and responsible management techniques.

Assessments

Supervised exercise

Bibliography

Les petites centrales hydroélectriques: Conception et calcul, by D. Le Gouriérès, published by Éditions du Moulin Cadiou in 2009. Available at the school's documentation centre

Introduction to energy challenges and transversal and societal aspects

Sustainable energy

Thierry Gaidon
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_ENE_INEE

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
34						**34**

Language
French

Team
– Thierry Gaidon
– Pascal Denis
– Nicolas Clootens

Objectives

– Students will be introduced to the importance for society of the sustainable energy challenge
– They will develop general knowledge around the topic of energy
– They will become familiar with the economic mechanisms associated with energy
– Through site visits, they will discover the reality of power plant installations

Programme

– Introduction to the notion of energy
– Classifying energy sources
– Energy sources and resources
– Geopolitical significance of different energy resources
– Economic mechanisms and model specific to the energy setting
– Visits to industrial sites: CEA Cadarache, hydro-electric factory

Skills

C1: Ecole Centrale engineers create value through scientific and technical innovation
C2: Ecole Centrale engineers master the complexity of the systems and issues they encounter.
C3: Ecole Centrale engineers conduct programmes.
C4: Ecole Centrale engineers apply ethical and responsible management techniques.
C5: Ecole Centrale engineers develop a strategic vision and know how to implement it.

Assessments

CA and SE

Bibliography

A.V. da Rosa, Fundamentals of Renewable Energy Processes, Academic Press, 2012

Transversal energy notions: transport, conversion, storage and electrical power

Sustainable energy

Mohamed Boussak
Head of theme at École centrale de Marseille

Crédits ECTS
2

Code de l'UE
ING_S8_ENE_NOET

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
20						**20**

Language
French

Team
– Mohamed Boussak
– Thierry Gaidon

Objectives

– The course presents the various transversal aspects relating to energy, such as the different energy conversion forms, energy transport, energy consumption and smart grids
– Students will master basic elements of conversion of primary energy sources into electricity, including energy transport, storage, consumption and smart grids
– They will understand the principles of functioning of electric machines working as motors or generators. The main topologies of electronic power converters linking electrical equipment (motor, alternator, electronic card, etc.) to a given source of energy (alternating network, battery, etc.) will be presented
– The various means of storing electricity and future technical and economic challenges will be discussed.

Programme

– Conversion of electrical energy into mechanical energy (electric motors): synchronous motors, asynchronous motors, principle of functioning, modelling, equivalent energy diagram, calculating coupling
– Conversion of mechanical energy into electrical energy (electricity generators, windmills): asynchronous and synchronous generation (alternator)
– Conversion of electrical energy into electrical energy: sources, switches, connection rules, switching cell, family of static converters (alternating-direct [AC/DC], direct-direct [DC/DC], direct-alternating [DC/AC] converters, principles, advantages and disadvantages of structures, three-phase transformer)
– Electricity transport
– Using electricity (rail traction, transport [terrestrial, aeronautical, maritime], industrial processes, pumping, domestic appliances, lighting, buildings, etc.)
– Storing electricity (chemical accumulators, fuel cells, super capacitor, flywheel, etc.)
– Presenting smart grids, which link different localised (power plant) or distributed (solar panels or other) energy forms in a distribution network; and provide for a complex consumption pattern (domestic, industrial, public works, etc.)

Skills

C1: Ecole Centrale engineers create value through scientific and technical innovation
C2: Ecole Centrale engineers master the complexity of the systems and issues they encounter.
C3: Ecole Centrale engineers conduct programmes.
C4: Ecole Centrale engineers apply ethical and responsible management techniques.

Assessments

Supervised exercise

Bibliography

Course notes

Project

Sustainable energy

Fabien Anselmet
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_ENE_PROJ

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
				30		**30**

Language
French

Team
– Thierry Gaidon
– Pascal Denis

Objectives

– Students will grasp the complexity of implementing a sustainable energy project in a town in Southern France
– They will grasp the mechanisms behind local, departmental, regional, national, or European decisions
– They will learn to consider the energetic, socio-economic and financial challenges associated with this type of project
– They will implement the knowledge acquired during the different courses in their academic trajectory

Programme

Groups of students will be attributed a town in Southern France and asked to propose a sustainable energy project for it.
They will have to perform a local analysis of energy usage and production, review the available resources, consider the town's current and future financial situation.

The towns will differ on several aspects (tourism, industry, specific geographical location, size, financial resources, etc.).

Several timepoints are proposed as steps in the implementation of students' projects. In some cases, contacts may be established with departments in the towns studied.

Communication skills will be implemented when producing the project report, as will a capacity for critical analysis as students are included in the examination committee.

Skills

C1: Ecole Centrale engineers create value through scientific and technical innovation
C2: Ecole Centrale engineers master the complexity of the systems and issues they encounter.
C3: Ecole Centrale engineers conduct programmes.
C4: Ecole Centrale engineers apply ethical and responsible management techniques.
C5: Ecole Centrale engineers develop a strategic vision and know how to implement it.

Assessments

Group report and presentation

Bibliography

Regional energy atlas

Coding and seeking information

Information science and a digital society

Pascal Prea
Head of theme at École centrale de Marseille

Crédits ECTS
4

Code de l'UE
ING_S8_SIS_CRI

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
25		20				**45**

Language
French

Team
– E. Daucé
– T. Durt
– P. Préa
– M. Roche

Objectives

The search for and extraction of information involve the implementation of a system that is capable of finding an element (structure, text, visual, sound, etc.) in response to a user request. This TU aims to present the main tools to search, recognise, extract, shape, and communicate information to students, who will be able to model, select and implement the whole system and thus obtain relevant information.

Programme

Text mining (8 h Lectures, 12 h Practical: E. Daucé)
This module relates to the analysis of text-based data using algorithms.

Images (4 h Lectures + 8 h Practical: M. Roche). Human visual perception and Practical on image transfer and image quality using aspects of human vision

Quantum information (6 h Lectures: T. Durt)
Quantum information theory is the result of mixing between two major 20th century theories, quantum theory and information theory. The aim of this module is to provide an overview of this new discipline and distinguish between the theoretical utopia and practical implementations.

Cryptography (5 h Lectures: P. Préa, 2 h Lectures: T. Durt)
Since its invention in antiquity, cryptography has continuously evolved. It has recently undergone a significant paradigm shift thanks to the introduction of public key methods. This module is the follow-up to the ESN TU on cryptography, during which we reviewed the various techniques.

Skills

- Students will develop technical and scientific innovations (capacity to stimulate the imagination, capacity to analyse a context, capacity to draw on general scientific/technical knowledge, capacity to invent creative, ingenious, novel solutions)
- Solve complex and cross-disciplinary problems (capacity to understand and formulate a problem, capacity to take the uncertainty generated by complexity into account, capacity to converge towards an acceptable solution)
- Develop and conduct international scientific and technical projects (capacity to rapidly expand on a field)

Assessments

CA (written exam + write-up) 100% of the final grade

Bibliography

None

Strategic challenges for digital systems

Information science and a digital society

Muriel Roche
Head of theme at École centrale de Marseille

Crédits ECTS
4

Code de l'UE
ING_S8_SIS_ESN

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
43	2	3		3		**51**

Language
French

Team
– T. Artières
– E. Daucé
– C. Fossati
– D. Henriet
– C. Jazzar
– P. Préa
– Ph. Réfrégier
– M. Roche

Objectives

This module draws on various disciplines to present the strategic potential of digital systems.
The aim of this teaching is to provide students with a good knowledge of the challenges, orders of magnitude, evolution and performance of digital systems and industrial computing. The representation and modelling of knowledge and reasoning will also be studied, as they are widely used, in particular in AI.

Programme

Randomness and determinism in science and technology (4 h Lectures, 2 h Tutorial: Ph. Réfrégier)
Review of the introduction of randomness to 20th century physics, its consequences, and discussion of its role in data-treatment technologies.

Economy (2 h Lectures, 3 h Practical [oral presentation], 3-h project: D. Henriet)
– growth and dissemination of information technology and digital technology

Machine learning and Deep Learning (4 h Lecture: Th. Artières)
The strategic opportunities presented by Deep Learning and machine learning are presented.

Computational neurosciences (6 h Lectures: E. Daucé)
Introductory module presenting the main issues associated with modelling how the brain treats data.

Human visual perception (4 h Lectures: M. Roche)
Which factors can explain how we perceive the world around us? Various aspects will be studied: anatomical, psychological, cognitive.

Cryptography (3 h Lectures: P. Préa): cryptography

Problems with representations of knowledge (10 h Lectures: C. Jazzar)
Working from symbolic representations of knowledge and using the notion of heuristics, artificial intelligence (AI) systems allow parallels to be drawn with the real world.

Material treatment of information (6 h Lectures: F. Fossati)
Faced with the extremely rapid evolution of electronic components and their technology, engineers must have general knowledge in this field to allow them to anticipate and adapt to technological changes.

Seminars (4 h Lectures): external speakers

Skills

This module aims to provide students with a broad view of the economic, scientific and technological challenges associated with digital applications.
It thus aims to develop students' capacity to define a long-term strategy and identify interactions between elements.

Assessments

– CA1: "Randomness and determinism in science and technology" and "Human visual perception" 40-min written exam = 23%
– CA2: "Economy" oral = 18%.
– CA3: "Computational neuroscience" write-up = 14%
– CA4: "Cryptography" write-up = 8%
– CA5: "Representation of knowledge" mean of three 20-min written exams set during lecture slots = 23%
– CA6: "Material treatment of information" write-up = 14%

Bibliography

None

Information and classification

Information science and a digital society

Antoine Roueff
Head of theme at École centrale de Marseille

Crédits ECTS
4

Code de l'UE
ING_S8_SIS_ICL

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
20	4	22				**46**

Language
French

Team
– Th. Artières
– Ph. Réfrégier
– A. Roueff

Objectives

The objective of this course is to provide students with foundations in information theory and its applications in diverse fields, such as digital applications, physics and pattern recognition.
During practical sessions, students will have an opportunity to become familiar with data-classification techniques and machine learning, in particular by tackling techniques based on neural networks.

Programme

Foundations of information theory and classification (12 h Lectures, 4 h Tutorial: Ph. Réfrégier)
Information theory provides a qualitative measure of the notion of information provided by a message or observation. The founding elements of information theory will be presented, not only for its applications in the field of data treatment, but also through its links with other scientific fields, particularly physics and statistics. Notions relating to entropy, information and complexity will thus be addressed from a broad perspective. The basics of the issue of statistical classification will also be presented.

Statistical pattern recognition (6 h Lectures, 16 h Practical: A. Roueff)
The aim of this module is to present the issue of statistical decisions as part of detection, and classification with or without an a priori probabilistic model. This module is structured around practical sessions using examples to demonstrate to students how performance analysis can be used to choose between various techniques.

Machine learning and neural networks (2 h Lectures, 6 h Practical: Th. Artières)
This module introduces the general principles of statistical machine learning and neural networks (multilayer perception and convolutional models) for supervised classification and data production.

Skills

- Students will develop technical and scientific innovations (capacity to stimulate the imagination, capacity to analyse a context, capacity to extend a tool or concept for other uses, capacity to logically and methodically collect and analyse information, capacity to draw on general scientific/technical knowledge)
- Solve complex and cross-disciplinary problems (capacity to understand and formulate a problem, capacity to recognise the specific elements of a problem, capacity to identify interactions between elements, capacity to account for the uncertainty generated by complexity)
- Develop and conduct international scientific and technical projects (capacity to rapidly expand on a field)

Assessments

– CA1 ("Foundations of information theory and classification" part): 1-h written exam - Proportion of grade = 35%
– CA2 ("Recognition of statistical shapes" part): robust average for write-ups - Proportion of grade = 45%
– CA3 ("Machine learning and neuronal networks" part): project - Proportion of grade = 20%

Bibliography

– Ph. Réfrégier, Noise theory and application to physics - Springer, 2003
– T.M. Cover and J.A. Thomas, Elements of information theory - Wiley, 2006
– R.O. Duda, P.E. Hart and D.G. Stork, Pattern Classification - Wiley, 2001

Project

Information science and a digital society

Antoine Roueff
Head of theme at École centrale de Marseille

Crédits ECTS
2

Code de l'UE
ING_S8_SIS_PROJ

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
				19	13	**30**

Language
French

Team
A. Roueff and all ECM teaching staff

Objectives

The objective of this TU is to provide S8-SISN students with an opportunity to perform a technical study or analyse the challenges raised by a given issue. This teaching promotes team work, as students will work in groups, potentially mixing with students from IEP Aix-en-Provence.
Students will thus learn to mobilise their knowledge to solve a technical problem or consider the challenges linked to an issue which may be societal, or linked to data regulations.

Programme

The study topics are explained to students during a presentation session. These topics may be proposed by a teacher from ECM, by an external partner (non-profit, company, lab, etc.), or by the students themselves. Each project is tackled by a team, with a minimum of two members, and a maximum of four. For each project, a tutor is appointed from among the teaching staff to help guide students in their options. Students' work is assessed during a final oral presentation. Before this final oral presentation, students have the option to test their capacity to present their work during an intermediate oral presentation.

Skills

- Students will acquire the capacity to analyse a context and present results
- The capacity to draw on general scientific/technical knowledge to identify challenges
- The capacity to invent creative, ingenious, novel solutions
- The capacity to propose one or more potential solutions
- The capacity to identify interactions between elements

Assessments

– CA1 = oral - Proportion of final grade = 50%
– CA2 = write-up - Proportion of final grade = 50%

Bibliography

None

A digital society: challenges and regulation

Information science and a digital society

Laetitia Piet
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_SIS_SNER

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
10	9	16		8		**43**

Language
French

Team
– L. Piet
– D. Roynard
– B. Prince

Objectives

General engineering students will gain a general knowledge of social sciences and law to allow them to assess the societal issues linked to information technology and digital science. This TU contributes to developing students' capacity to analyse the complex challenges presented by digital technology from ethical, social, political and legal standpoints, at national and international levels. It draws on their capacity to gather and analyse information in a logical and methodical manner to decipher situations presenting ethical and legal conflicts.

Programme

Ethics (16 h Practical [= 10 h Practical: L. Piet and B. Prince + 6 h Practical: B. Prince] + 8 h projects)
- General context of the ethical issues raised by digital systems
- Extension to an ethical topic selected and treated by a group

Sociology (4 h Lectures, 5 h Tutorial: L. Piet)
- Sociohistory: origins of the Internet and the World-Wide Web
- Political regulation of digital systems: challenges for democracy
- Digital habits: sociability and identity

Law (6 h Lectures, 4 h Tutorial: D. Roynard)
- Supervising active parties in digital technology: intellectual property, privacy protection, contract regulation
- Legal regulations for questions relating to content and digital flow

Skills

- Students will learn to present economic, standardisation, ethical, conciliatory, and conflict resolution scenarios
- Learn to assess the societal impact of the regulatory forms predominating in various ICT fields (e.g. relations between users and access providers, regulations relating to intellectual property laws and dissemination of knowledge and culture, etc.)
- Learn to adopt the stance of an active party (designer and/or user) with respect to the technical potential of ICT

Assessments

– Law exam based on a 1-h written test: 33%
– CA in ethics, written part (portfolio): 33%
– CA in ethics, oral (oral presentation): 33%

Bibliography

None

Telecommunications and information technology

Information science and a digital society

Salah Bourennane
Head of theme at École centrale de Marseille

Crédits ECTS
4

Code de l'UE
ING_S8_SIS_TTI

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
44	4	8				**56**

Language
French

Team
– S. Bourennane
– L. Gallais
– F. Galland
– A. Khalighi
– C. Fossati
– P. Préa
– J.-C. Antonna

Objectives

The objective of this module is to present applications, and advanced technology for the treatment, analysis, communication and display of digital data in a broad sense. The presentation will adopt a transversal vision to discuss system components and real-world applications of information theory in the digital and telecommunications field. The practical and conceptual consequences in other scientific fields, particularly in physics, will also be addressed (propagation, transmission, etc.).

Programme

Digital micro-electronics (6 h Lectures, 4 h Tutorial: C. Fossati)
In the constantly evolving context of micro-electronic technology, the study of the architecture of information treatment, whatever its source, is an important aspect in training engineers.

Information theory - Applications (12 h Lectures: S. Bourennane)
The aim of this module is to implement the practical concepts of information theory by considering a few applications such as data compression, transmission, storage and treatment. The various advanced applications of information theory in telecommunication will also be reviewed.

Telecommunications
- Optic-fibre-based telecommunications (4 h Lectures - J.-C. Antonna); network capacity and physical effects during propagation (distortion, noise)
– Network protocols (2 h Lectures - P. Préa); the OSI model will be presented along with the IP protocol (v4 and v6)
– Telecommunications networks (8 h Lectures: A. Khalighi); wireless networks (mobile telephones; local, personal and extended networks; wireless optics) and wired networks (ADSL, PLC); Smart grids; Internet of things for the Smart City and Smart Homes

Display system (6 h Lectures: L. Gallais)
Presentation of the essential screen-related scientific and technological considerations

C programming language (6 h Lectures, 8 h Practical: F. Galland)
This module aims to provide students with an experimental methodology in computer science:
- quality, validity and efficacy in programming (application in C);
- introduction to, and awareness of, problems in numerical calculations.

Skills

- Students will develop technical and scientific innovations (capacity to stimulate the imagination, capacity to analyse a context, capacity to draw on general scientific/technical knowledge, capacity to invent creative, ingenious, novel solutions)
- Solve complex and cross-disciplinary problems (capacity to identify the specific aspects of a problem, capacity to propose one or more solution scenarios, capacity to identify interactions between elements, capacity to account for the uncertainty generated by complexity)

Assessments

– CA1: “Digital microelectronics”: average of grades for two written exams taken during course time = 25%
– CA2: “Information theory - applications”: average of grades for write-ups and written exam taken during course time = 25%
– CA3: “Telecommunications” and “Display system”: average of grades for write-ups and written exams taken during course time = 25%
– CA4: “C programming language”: average of grades for several assignments = 25%

Bibliography

Prerequisites: elementary computing, basic notions in signal treatment and photonics

Company - CEA 4 oral presentation

Semester 8 - Internship

Guillaume Graton
Head of theme at École centrale de Marseille

Crédits ECTS
24

Code de l'UE
N/A

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
					4	**4**

Language
French

Team
The teaching team is composed of ECM tutors who attend the oral presentations and help the interns if any problems arise.

Objectives

The "Skills through internships" module aims to train interns to complete a specific mission in a company. Interns are supervised during internship periods by a "career tutor" and a "school tutor". The objective is to become familiar with a specific setting, adopt the codes of conduct, understand how the structure functions, develop innovative solutions to move the project forward.

For semester 8, the aim is to integrate the skills and knowledge accrued during the first three semesters. Semester 8 can be an opportunity for the intern to experience new structures, new ways of working, and new work organisations through international mobility.

Programme

During this period, the intern must maintain regular contact with their "school tutor", to keep them informed of the mission and its progression. The module ends with two assessments: a school assessment based on an oral presentation, and a career tutor assessment.
The important points are as follows:
• training (basic knowledge, aptitude for learning, analytical capacity, capacity to summarise, creativity and level of innovation);
• work and results (based on quality, quantity, efficacy, achievement of objectives, meeting deadlines, grasp of the subject, mastery of the subject)
• personality (initiative, sociability, contacts established, interests, motivation, sense of responsibility, method and organisation, communication, open-mindedness, judgement and realism)

Skills

The oral presentation in semester 8 is individual. It lasts 20 minutes and is held in September (start of the 3rd year) and serves to present the work performed; it is linked to the written report, and describes the challenges, context, solutions imagined, solution retained, implementation and results.

Assessments

The module includes an oral presentation by a group of five or six interns and an assessment by the career tutor.
The two assessments are awarded a lettered grade (A: Excellent, B: Very good, C: Good, D: Quite good, E: Pass, F: Fail).
The final grade is the average of the grades from the two assessments; when the average is difficult to determine (e.g. A and B), the assessment by the "career tutor" takes precedence.

Bibliography

As this teaching unit is very specific to each internship, there is no and cannot be any general bibliography.

Internship

Core course

Guillaume Chiavassa
Head of theme at École centrale de Marseille

Crédits ECTS
6

Code de l'UE
ING_S8_TC_STG

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
						99

Language
French

Team
– G. Chiavassa, head of internships
– All the teaching staff at Centrale Marseille may be tutors for this internship.

Objectives

The 2nd year internship corresponds to a placement as an assistant engineer during which students will discover the engineering profession. Students will be expected to perform a typical engineering or research project by taking an active role within a team. Students will be expected to contribute to analysis and proposals.

Programme

The 2nd year internship can take place either within a company or in a laboratory, in France or abroad. It lasts between two and three months (minimum of eight weeks) between June and August.

Skills

C1: Scientific and technical innovation
C2: Mastery of the complexity of systems

Assessments

In addition to the report and assessment of the company, students will present orally to an examination panel consisting of their school tutor and another teacher. Modalities of the oral presentation: 20-minute presentation, followed by questions/discussion with the examining panel.

Bibliography

https://stages-emplois.centrale-marseille.fr/content/informations-importantes-et-foire-aux-questions#FAQ-stage2A

Languages - International culture

Core course

Carole Enoch
Head of theme at École centrale de Marseille

Crédits ECTS
3

Code de l'UE
ING_S8_TC_LCI

Volume horaire (élève) total de l'UE

CM	TD	TP	TA	Projets	Autres	Total
	40				20	**60**

Language
Anglais

Team
– German: D. Ortelli-Van-Sloun
– English: J. Airey, Pk. Atkinson, V. Durbec, G. Marquis
– Chinese: J. Dong
– Spanish: S. Duran, C. Enoch, E. Muñoz
– French as a foreign language: V. Hamel (+ French as mother tongue)
– Italian: S. Canzonieri
– Japanese: A. Futamata

Objectives

Languages and culture are essential elements in the training of internationally aware and responsible citizens and engineers.
Engineers graduating from Ecole Centrale Marseille must be able to interact precisely and effectively with partners in a number of languages and/or from different cultures, in particular in an occupational environment.
Graduates will be capable of mobilising linguistic, conceptual, cultural and communicational knowledge and skills. To do so, they will acquire information relating to practices, events and/or historical, cultural, social, economic and political phenomena. They will stimulate their imagination through cultural exploration and taking differences into account by varying their representations. They will develop their critical faculties.

Programme

L&C teaching includes two distinct branches of teaching: English (LL1) 20 h and another language 20 h (LL2).
These 40 hours of on-site lessons are complemented each semester by 10 h of personal work (independent work, research, exercises, etc.) for each language.
L&C are taught at a volume of two hours per week for each language. Students enrolled in English choose the theme of their lessons (society, current events, civilisation, etc.).
For beginner level LL2 students in first year, students will have 10 hours (Italian, Spanish, Portuguese) or 15 hours (German, Chinese, Japanese, Russian) of complementary remedial lessons.
N.B. Students will not be able to start a language in semester 8.
-> See the factsheets for each language to discover the detailed teaching programme

Levels and obligatory external certifications to validate the diploma/degree
- In English and French as a foreign language, the target level following the course is level C1 on the CEFRL.
In line with the Regulations of studies, all students must obtain an external certification in English (minimum level required B2+, or TOEIC 850).
International students must also validate a minimum B2 level on CEFRL in French as a foreign language (Delf B2 or Dalf C1 C2). Note: other students must validate a level of French as their native language (Orthodidacte level 3).
– For other languages, the target level is B2, or C1 depending on the student's academic trajectory. It is recommended that an external certification be obtained to certify the highest level obtained at the end of the training.
-> See the descriptors of the different levels in the Common European Framework of Reference for Languages (CEFRL): https://www.coe.int/en/web/portfolio/self-assessment-grid

Skills

– C1: Production + fluency
– C2: Represent and model + resolve and arbitrate + think and act in an unpredictable and uncertain environment
– C3: Design a project, a programme + manage, lead
– C4: Generate individual and collective performance + lead transformations of their organisation (identify needs / hurdles when effecting changes, etc.)
– C5: Anticipate and commit + construct and sustain (analyse an organisation's strategy with respect to local, global or other challenges)

Assessments

- The L&C TU is divided into two language courses (CA1 LL1 50% + CA2 LL2 50%). A pass grade of 10/20 is set, with a minimum of 7/20 required to validate the course
- Assessment of the five CEFRL skills + assessment of knowledge acquired (lexicon, conjugation, civilisation, etc.)
Attendance is mandatory (maximum of two absences)

Bibliography

Specific for each language