



2011-2012

Year One & Year Two Curriculum

G1 – G2 Core Curriculum

2011-2012

Curricular Harmonisation: 48 hours

Depending on each student's academic background:

- Mathematics - Computer Science

or

- Engineering Sciences: choice of 3 modules from Control Engineering, Electrical Engineering, Mechanics and Fluid Mechanics

Unit	Academic discipline	Total no. Student Hours	Lectures	Tutorials	Seminars	Lab Work	PBL	Unsupervised work	Test	Exams	Continuous Assessment	Semester		
												S5	S6	S7
1	Probability, Integration and Transforms	48	16	30	-	-	-	-	2	1.00	-	•		
	Numerical Analysis and Optimisation	32	10	20	-	-	-	-	2	0.67	0.33			•
	Complexity and Advanced Algorithms	48	9	15	-	16	-	8	-	-	1.00	•		
2	Information Systems Modelling and Microcomputing	32	5	14	9	-	-	4	-	-	1.00		•	
	Signal Processing	32	8	10	-	12	-	-	2	0.67	0.33		•	
	Electrical Networks and Electronic Energy Conversion	32	6	6	-	8	10	-	2	1.00	-	•		
	Electromechanical Conversion and Speed Control	32	10	10	-	4	-	6	2	1.00	-		•	
	Electronic Systems	32	-	-	14	16	-	-	2	0.50	0.50			•
3	Control Engineering	32	8	10	-	12	-	-	2	0.50	0.50			•
	Introduction to Solid-State Physics	32	14	8	-	8	-	-	2	0.50	0.50	•		
	Transport Phenomena	32	3	2	25	-	-	-	2	1.00	-	•		
	Thermodynamics and Matter	32	10	6	-	-	14	-	2	1.00	-		•	
	Aero-Hydrodynamics	32	7.5	12	-	8	-	2.5	2	0.67	0.33			•
4	Materials Science	32	2	10	-	12	-	6	2	0.50	0.50			•
	Structural Mechanics	32	-	-	24	-	-	8	-	-	1.00	•		
	Mechanics of Mechanisms	32	-	17	4	-	3	6	2	0.75	0.25	•		
	Systems Design	32	-	2	4	8	-	8	-	-	1.00		•	
	Dimensioning of Systems	32	6	-	8	9	4	3	2	0.50	0.50		•	
5	Design and Manufacture	32	-	1	8	12	9	-	2	0.67	0.33		•	
	Working Culture and Communication Skills	32	-	6	-	18	-	8	-	-	1.00		•	
	Sociology of Organisations	32	10	8	-	-	-	12	2	0.67	0.33	•		
	Business Accounting and Finance	32	6	4	12	-	-	8	2	0.67	0.33	•		
	Economics	32	10	10	-	-	-	10	2	1.00	-		•	
	Management	48	10	20	-	-	-	18	-	1.00	-			•
	Law	32	32	-	-	-	-	-	-	-	1.00			•
5	English	96	-	96	-	-	-	-	-	-	1.00	•	•	•
	Other language (German, Spanish, Chinese, Japanese, FFL)	96	-	96	-	-	-	-	-	-	1.00	•	•	•
	Assistance	96	-	-	-	-	-	-	-	-	1.00	•	•	•
	TOTAL	1136	183	413	108	143	40	107.5	36	14.27	13.73			
G2 WORK PLACEMENT														

Discipline-based elective modules 2011-2013

Department	Title	Semester
Engineering	Innovation	S6
Business Studies	Financial Analysis	S6
Mathematics & Computer Science	Computer Network Engineering	S6
	Introduction to Decision Support Systems	
	Mathematics and Cryptography	S7
	Relational Database	
	Web Technologies	
	Knowledge Engineering and Logic Programming	
	Distributed Optimisation and Multi-Agent Systems	S8
	Embedded Linux	
	Design of Experiments	
	Decision Aid for Large-Scale Systems	
Wavelets and their Applications		
Electronic, Electrical and Control Engineering (EEA)	Automation of Systems	S6
	Sensors and Actuators	
	Lighting and Energy Efficiency	
	Photovoltaics	
	CAD for Electronic Systems	S7
	Industrial Computer Systems	
	Dynamic Modelling and Simulation of Multiphysics Systems	
	Force Feedback Interfaces and Virtual Reality	
	Mobile Robotics – Case Studies	
	Distribution of Electrical Energy	
	Multiphysics Simulation in MATLAB	S8
	Vibrations and Audible Acoustics	
	Control of Dynamic Systems	
	Electric Actuators	
	New and Emerging Digital Technologies	
	Digital and Algorithmic Tools for Control Engineering	
	Soft Computing and Metaheuristics for Optimisation and Decision Aid Systems	
	Design and Control of Robotised Workshops	
	Programmable Digital Electronics	
Subsurface Imaging		
Electric Vehicles and Urban Mobility: Speed Control		
Machine Vision and Image Processing		

Department	Title	Semester
Physical Sciences	Experimental and Numerical Fluid Mechanics	S6
	Quantum Physics	
	Processing Techniques of Today and Tomorrow	
	Distillation	S7
	Fluid Energetics	
	Experimental Methods in Materials Science	
	Material Selection	
	Kinetics and Reactors	
	Wave Imaging Systems	S8
	Failure of Materials: Corrosion and Remedies	
	Aerodynamics for Transport Systems	
	Fluid Transfer Devices	
	Production of Industrial Materials	
Mechanisms, Structures and Construction	Advanced Structural Design Analysis	S6
	From Functions to Mechanisms	
	Dynamic Simulation of Mechanical Systems	
	Advanced CAD	S7
	Prototype Production for Project	
	Fabrication: from Virtual to Real	
	Data Acquisition and Numerical Methods for Engineers	
	Finite Element Analysis in Systems Design	
	Computer-Aided Analysis Tools for Systems Design	
	Rapid Prototyping: from Virtual to Real	
	Durability of Geomaterials	S8
	Experimental Methods in Mechanics of Materials	
	Combined Experimental-Modelling Approach in Mechanics of Materials	
	Modelling and Generation of Skew Surfaces	
	Science of Friction	
	Process – Property Relationships	
	Quality and Production Control	
	Automotive Technologies and Design	
	Failure of Materials: Fatigue and Reliability of Structures	
	Geotechnics: from Basics to Professional Applications	
Continuum Mechanics: Linear Elasticity		
Behaviour of Heterogeneous Materials		

- Architectural Design and Sustainable Construction
- iNnovative ExperiMEnts for engineering ScIenceS (NEMESIS)
- Business Modelling and Management
- Telecommunications Networks
- Energy Strategy and Alternative Electricity Generation
- High-Speed Transport
- Towards Sustainable Materials
- Bioengineering
- From Heat Engines to Hybrid Systems
- A Responsible Approach: Ecodesign
- Ambient Intelligence

Department of Mathematics/Computer
Science

Curricular Harmonisation in Mathematics

Department: *Mathematics-Computer Science*

Year: *G1*

Category: Curricular harmonisation

Semester: *S5*

Duration: *24h*

Organisation:

Assessment:

Specific rooms:

Prerequisites:

Lecturer(s): B. Trouillet

Objectives.

Acquire the basic concepts of topological structures, linear algebra (reduction), integration and differential equations in order to supplement previously acquired knowledge during PT or ATS preparatory classes. These concepts are vital prerequisites for the Probability, Integration and Transforms (Year One) and Optimisation (Year Two) modules.

Knowledge:

Skills:

Module Content Summary.

- Linear algebra – Vector space, matrices, determinants, reduction of endomorphisms
- Analysis – Integral calculus, parameter-dependent integrals, the Laplace transform, differential equations
- Basic topological concepts – Set theory, metric space, normed vector space, convergence concepts

Curricular Harmonisation in Computer Science

Department: *Mathematics-Computer Science*

Year: *G1*

Category: *Curricular harmonisation*

Semester: *S5*

Duration: *16h or 24h*

Organisation: *Four to six 4h seminars, depending on student's academic background*

Assessment:

Specific rooms: *Computer labs*

Prerequisites:

Lecturer(s): F. Semet, P. Vanheeghe, S. Hammadi, K. Mesghouni, S. El Khattabi, T. Bourdeaud'Huy, C. Vercauter + ATER(s) (Temporary Teaching and Research Fellows)

Objectives.

Knowledge:

Design iterative and recursive algorithms based on elementary data structures, and implement them in imperative and procedural programming languages.

Skills:

Use an integrated development environment adapted for programming in C. Incremental decomposition and development of a computer application.

Module Content Summary.

- Basics of programming in C and introduction to the Microsoft Visual Studio C++ development environment
- Iterative algorithms and elementary data structures: scalars and arrays
 - Decomposing a problem
 - Defining and using functions
 - Parameter passing mechanisms
 - Pointer concept
- Recursive algorithms and application to character string processing
- Modular application development

Probability, Integration and Transforms

Department: *Mathematics-Computer Science*

Year: *G1*

Category: *Core curriculum*

Semester: *S5*

Duration: *48h*

Organisation: *16h lectures/ 30h tutorials/2h assessment*

Assessment: *Exam*

Specific rooms: -

Prerequisites: -

Lecturer(s): A. Mouze

Objectives.

Study the basic mathematical tools used in Engineering Science. Students will be given a grounding in probability and statistics, which are the foundations of the modelling of random phenomena. They will also study the theory of distributions, which is essential for understanding signal processing, as well as functional transforms such as the Laplace transform.

Knowledge:

Basic mathematical tools used in Engineering Science.

Skills:

Apply knowledge to solve classic mathematical problems in engineering or model random phenomena, etc.

Module Content Summary.

- Measure theory
- Theory of integration and application to the Fourier transform
- Probability theory (probability concepts, probability space, random variables, law of a random variable, transfer formula, sequences of random variables, law of large numbers, central limit theorem and common approximations)
- Introduction to the theory of distributions
- The Laplace transform (functions and distributions)

Numerical Analysis and Optimisation

Department: *Mathematics-Computer Science*

Year: *G2*

Category: *Core curriculum*

Semester: *S7*

Duration: *32 h*

Organisation: *Six 2h lectures (lecture theatres). Eight 2h tutorial sessions. One 4h lab session.*

Assessment: *Two components: Exam 2/3*

Continuous assessment 1/3

Specific rooms: *Computer lab (lab session)*

Prerequisites:

Lecturer(s): *F. Semet , P. Brochet*

Objectives:

Knowledge:

Be able to formulate and solve classic mathematical problems numerically

Skills:

Numerical solution of mathematical problems involving systems of linear or non-linear equations and systems of differential equations.

Solution of problems involving linear or non-linear optimisation.

Module content summary:

Numerical Analysis:

- Machine representation of numbers and error analysis
- Non-linear equations
- Interpolation
- Differential equations

Optimisation

- Basics of linear programming:
Convexity and linear programming (General definitions, Supporting hyperplane, Linear programming formulation, Farkas' Lemma) – Duality (Definition, Duality theorem, Complementary slackness theorem) – Simplex algorithm
- Basics of non-linear programming:
Optimality conditions – Unconstrained optimisation (method of steepest descent, Newton's method, conjugate direction method) – Constrained optimisation (permissible directions method)

Complexity and Advanced Algorithms

Department: *Mathematics-Computer Science*

Year: *G1*

Category: *Core curriculum*

Semester: *S5*

Duration: *48h*

Organisation: *Six sessions comprising one lecture (1.5 hours in lecture theatre) followed by one tutorial session (2.5 hours).
Five supervised lab sessions in computer lab.
One unsupervised lab session.*

Assessment: *Continuous assessment + test*

Specific rooms: *computer labs*

Prerequisites: *Curricular harmonisation in computer science.*

Lecturer(s): F. Semet, P. Vanheeghe, S. Hammadi, K. Mesghouni, S. Collart-Dutilleul, S. El Khattabi, T. Bourdeaud'Huy, C. Vercauter + ATER (Temporary Teaching and Research Fellow)

Objectives.

Knowledge:

Be able to select the most suitable data structures and processing algorithms for solving various computer science problems; this involves studying the main types of data structures (lists, trees, graphs), analysing the performance of the relevant algorithms and developing the chosen solution in a procedural and imperative language.

Skills:

Use a development environment and fine-tune applications written in C.

Use tools for producing scientific representation of data (*GnuPlot*), graphs (*Graphviz*) and documentation (*Doxygen*).

Module Content Summary.

- Introduction to data structures
 - Concepts of abstract data type
 - Stacks and queues: static and dynamic implementation and applications
- Algorithm analysis and complexity
 - Introduction and principles
 - Orders of magnitude and Landau's asymptotic notation
 - Complexity classes and examples
 - The case of recursive algorithms
 - "Main" theorem
 - The "Divide and Conquer" principle: application to sorting
- Arborescent data structures
 - Binary search trees
 - Self-balancing binary trees
 - Partially ordered trees
 - Applications to sorting and compression
- Graph representation and algorithms
 - Graph representation
 - Graph traversal
 - Shortest path problems

Modelling Information Systems

Department: *Mathematics-Computer Science*

Year: *G1*

Category: *Core curriculum*

Semester: *S6*

Duration: *24h*

Organisation: *5 sessions comprising:*

- *1-hour lectures (half the class at a time)*
- *3-hour tutorials in groups*
+ 1 self-study session

Assessment: *MCQ + tutorial work + self-study write-up*

Specific rooms:

- *Lecture: lecture theatre*
- *Tutorials: computer lab*
- *Self-study: computer lab*

Prerequisites: *None*

Lecturer(s): Jean-Pierre Bourey (lecturer-in-charge), Nordine Benkeltoum, Michel Bigand, Didier Corbeel, Emmanuel Duflos, Christian Vercauter, Philippe Vanheeghe, temporary lecturers

Objectives.

- Be able to explain
 - What constitutes an information system (IS)
 - The components of this system
- Be able to model the "data" portion of an IS
- Be able to explain the basic transformations of a data model into scripts for relational databases.

Module Content Summary.

- Introduction:
 - Introduction to the module, Information Systems and Relational Databases, Developmental approach, Class diagrams, Object diagrams
- Aggregation, composition, class association, Conversion of a class diagram into an RDB
- Generalisation specialisation, abstract class, Package diagram, Conversion of a generalisation hierarchy into a relational database
- Relational model, functional dependencies, normalisation
- Physical Model, Code generation, Introduction to SQL, Summary case study

Computer Network Engineering

Department: *Mathematics-Computer Science*

Category: *Discipline-based elective module*

Semester: *S6*

Duration: *32 h*

Organisation: *Lectures, lab sessions*

Individual work: *8 h*

Assessment: *Case studies, MCQs*

No. of students: *32 students maximum in groups of 16*

Room/Materials: *Network lab (B7-01)*

Prerequisites: *None*

Lecturer(s): Samir El Khattabi, Armand Toguyeni, Christian Vercauter

Objectives.

The main objective of this elective is to introduce students to the various concepts relating to computer networks through a series of lectures and a practical application with the CISCO platform.

The following points will be covered:

- Foundations of computer networks:
 - Concepts, Classification, Commutation
 - Transmission : circuits, modes, encoding, hardware aspects
 - Faults: detection, solutions
- Computer network standards:
 - Concepts of the layer model: protocol, interface
 - Reference model: OSI
 - Network access methods
- Local network engineering (LAN):
 - LAN design
 - LAN implementation and commutation
- Internet network:
 - Internet model and OSI
 - Addressing and routing
 - Implementation of IP networks
- Virtual Local Area Networks (VLAN)
- Introduction to transport and application protocols

Assessment will be based on an MCQ test at the end of the module and at least two case studies. Attendance will also be taken into account.

Session schedule.

Session 1: Foundations and standards of computer networks

Session 2: Local networks & Ethernet

Session 3: Internet Protocol: Addressing & routing

Session 4: Internet Protocol: Subnetting, CIDR, Private addressing, Address translation

Session 5: Unsupervised work: IP case study

Session 6: Commutation & VLAN

Session 7: Introduction to routing protocols

Session 8: Unsupervised work: VLAN case study

Introduction to Decision Support Systems

Department: *Mathematics-Computer Science*

Year: *G1*

Category: *Discipline-based elective module*

Teaching semester: *S6*

Duration: *32h*

Organisation: *6 × 4h: lectures/tutorials/lab sessions + 8h self-study*

Assessment: *Continuous assessment + project*

Specific rooms: *- 1 PC lab/16 students*

Prerequisites: *None*

Lecturer(s): *D. Corbeel, C. Vercauter*

Objectives.

Knowledge:

Financial calculation and financial simulation. Analysis and decision aid.

Management of personal databases. Event-driven programming.

Skills:

Model a problem and choose the most suitable type of result representation, i.e. in graphical or tabular form.

Know how to use a database handler. Know how to use and programme Excel and Access software.

Module Content Summary.

Session 1 – Solving and optimising with the Excel Solver

Session 2 – Producing graphs and handling large data volumes in Excel

Session 3 – Building and querying an Access database: tables and queries

Session 4 – Filling and personalising databases: forms, states, etc.

Session 5 – Basics of application development in VBA (Part 1)

Session 6 – Basics of application development in VBA (Part 2)

Session 7 – Project (unsupervised work)

Session 8 – Analysis and simulation: financial applications

Decision Aid for Large-Scale Systems

Department: *Mathematics-Computer Science*

Year: G2

Category: *Discipline-based elective module*

Semester: S8

Duration: 32 h

Organisation: *Six 4h sessions.*

Assessment: *1 test + 1 lab session*

Specific rooms: *Computer lab (lab session)*

Prerequisites: *Numerical Analysis and Optimisation*

Lecturer(s): F. Semet, A. El Kamel

Objectives.

Knowledge:

Know how to define methodologies for dealing with decision problems in a complex management and/or industrial context

Skills:

Build a mathematical model for a decision aid problem relating to the management of large industrial systems.

Learn about the difficulties in solving this model.

Understand and improve resolution techniques.

Interpret solutions and assist the decision-maker in the decision-making process.

Use the XPRESS-MP software.

Module Content Summary.

Modelling in mathematical programming.

Complexity.

Resolution methods for decision problems:

- Branch and Bound method
- Polyhedral approach
- Lagrangian duality

Decomposition methods for solving large-scale systems.

Heuristics

Relational Databases

Department: *Mathematics-Computer Science*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7*

Duration: *32 h*

Organisation: *6 x 4h: lectures/tutorials/lab sessions + 8h self-study*

Assessment: *Based on attendance and project*

Specific rooms: *1 PC lab / 16 students*

Prerequisites:

Lecturer(s): D. Corbeel

Objectives.

Knowledge:

Client-server architecture of information systems.
Control of network services, application protocols.

Skills:

SQL language - Oracle server – PL/SQL language

Module Content Summary.

- SQL language
- Transactions and concurrent access
- Security and data confidentiality
- Logical views
- Client-server architecture: carry out a client-server project by using the Oracle relational server and the PL/SQL programming language
- PL/SQL language
- Application to databases
- Relational-server-side programming

Web Technologies

Department: *Mathematics-Computer Science*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7*

Duration: *32 h*

Organisation: *4h lab sessions totalling 28h (of which 4h will be assessed)*

Individual work: 4h – Developing a multimedia Web page

Assessment: *MCQ, report on unsupervised work*

Specific rooms: *Computer lab - including during unsupervised work*

Prerequisites: *No prerequisites. Future applicants for the position of Chair of E-commerce are advised to take this elective module.*

Lecturer(s): *T. Bourdeaud’huy, S. El Khattabi, A. Toguyeni, B. Trouillet*

Objectives.

Knowledge: Basic concepts of computer networks, HTTP protocol

Skills: Designing HTML pages, CGI scripts, PHP, CSS and Javascript

Module Content Summary.

- Structural layer: (X) HTML
- Display layer: CSS
- Interaction layer: Javascript, DOM
- Static Web unsupervised work
- Server-side dynamic Web, HTTP protocol, Introduction to CGI, Apache configuration, Introduction to PHP
- PHP and databases
- Unsupervised work: PHP and Multimedia
- Introduction to Ajax & JQuery

Knowledge Engineering and Logic Programming

Department: *Mathematics-Computer Science*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7*

Duration: *32 h (8 x 4h)*

Organisation:

Assessment:

Specific rooms: *2 PC labs*

Prerequisites:

Lecturer(s): D. Corbeel - T. Bourdeaud'huy – Anne-Françoise Cutting Decelle

Objectives.

Knowledge:

Integrating artificial intelligence techniques and software engineering with a view to building expert systems.
Logic Programming, Constraint Programming, Semantic Web

Skills:

Prolog language, RDF, RDFS, OWL, SPARQL

Module Content Summary.

- Logic programming: Prolog language
- Prolog – Lists
- Prolog – Generate & Test and Progressive Generation approaches
- Constraint Programming
- Unsupervised work
- Semantic Web: RDF, RDFS, CORESE software
- Semantic Web: OWL, PROTEGE software
- Unsupervised work

Distributed Optimisation and Multi-Agent Systems

Department: *Mathematics-Computer Science*

Year: G2

Category: *Discipline-based elective module*

Semester: S7

Duration: 32 h

Organisation: *Series of 2h or 4h lectures totalling 24 h.*

8 h – Systems design, optimisation and implementation (in the form of mini-projects).

Assessment: *Final exam and mini-project.*

Specific rooms: *Computer labs equipped with relevant software.*

Prerequisites: *basic knowledge of Object-Oriented Design and Programming.*

Lecturer(s): S. Hammadi

Objectives.

Operational Research (OR) encompasses all the analytical, synthetic and optimisation approaches for effectively solving complex real-life Decision Aid problems. As for Artificial Intelligence, it is a means of providing computer systems with intellectual abilities in the form of autonomous and interactive entities known as agents. Such systems are called Multi-Agent Systems (MAS). In this context, Distributed AI (DAI) involves the study of systems in which agents operate collectively and in a decentralised manner in order to carry out complex tasks to achieve objectives that may be partially or completely conflicting. Thus, DAI is a relevant, open and flexible method that enables faithful representations and strong orientation of the behaviour of complex systems. The combination of these two fields is an innovation that offers the possibility of building generic models for solving various Decision Aid problems, and that enables us to work on problems relating to many different sectors. Effective solutions may be obtained in a way that is far superior to traditional resolution techniques. This module is intended for students who wish to learn advanced modelling and optimisation approaches for complex systems, which will be of great use in both research and industry (e.g. logistics in the transport, health and crisis management sectors).

Module Content Summary.

- Introduction: complementarity between optimisation and specification. Definition of distributed systems. The emerging need for modelling and optimising complex and distributed systems.
- Optimisation approaches: exact methods and approximate methods. Differences between and limitations of these methods. Example applications.
- Artificial Intelligence and Multi-Agent Systems: definitions and characteristics, typology of agents (granularity, mobility, function), typology of interactions (coordination, cooperation, negotiation), relational typology of organisations (hierarchy, heterarchy: market, community, society), structural typology of organisations (emerging, business-support).
- Complex systems and software agents: Multi-Agent modelling of complex organisations. Modelling of structure and interactions, implementation of interaction protocols.
- Agent-Oriented Programming (AOP) and Multi-Agent platforms, example of the JADE (Java Agent DEvelopment Framework) platform. Example applications.
- Research and Development (R&D): MAS's and logistics optimisation in the transport, health and crisis management sectors.

Embedded Linux

Department: *Mathematics-Computer Science*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *4h lab sessions*

Individual work: 4 h

Assessment: *MCQ, report on unsupervised work, lab report*

No. of students: *Groups of 16 students (maximum) taught concurrently*

Room/Materials: *Computer labs B7-13 and B7-01 only - including unsupervised work*

Prerequisites:

Lecturer(s): Th. Bourdeaud'huy, S. El Khattabi

Objectives.

The aim of this elective module is to introduce the procedures for building an "embedded" operating system around a GNU Linux distribution by means of a "build from scratch" approach.

- The module will include an introduction to the architecture of the Linux operating system: kernel, modules, start-up, shared libraries, file system, drivers.
- Mechanisms of kernel recompilation will be developed so as to produce a specific small-sized kernel adapted for use in embedded boards with low memory capacity.
- Command-line tools will be replaced by generic BusyBox tools so as to reduce the final distribution size.
- The booting processes of PC-type architectures will be touched on (network booting, flash memory, USB flash drive), and the system will ultimately be adapted for "run in memory" usage that does not require the presence of a hard disk.
- Cross-compiling processes will also be presented so as to bear the distribution for various processors.
- Several test platforms with recent processors will be made available to allow students to experiment with the distributions created. Processor emulators will also be used.

Module Content Summary.

S1 – Introduction to the Linux operating system, file system commands, processes, authorisations

S2 – Redirections, Advanced File Systems, Regular Expressions

S3 – User environment, shell programming, Unix compilation, shared libraries, cross compiling

S4 – BusyBox, start-up of a Unix system

S5 – Kernel recompilation, Linux run in memory

S6 – Unsupervised work: USB flash drive

S7 – Cross compiling, Ben Nanonote

S8 – Buildroot, uClinux

Design of Experiments

Department: *Mathematics-Computer Science*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *Series of 4h seminars totalling 24h, and 8 h individual work - Case study and report*

Assessment: *Participation and quality of report*

Specific rooms: *no*

Prerequisites: *Probability and Integration*

Lecturer(s): P.Brochet

Objectives.

Knowledge:

Know how to make decisions in a random and uncertain context.

Know how to monitor and improve the performance of a system or process within the context of real or numerical experimental approaches.

Skills:

Understand and master quality management tools: parametric and non-parametric statistical tests, SPC, sampling plan.

Understand and master modelling and experimental optimisation techniques: regression and correlation, analysis of variance, design of experiments, screening and response surface methodologies, exploitation and optimisation.

Module Content Summary.

- Probability laws and models
- Hypothesis testing
- SPC
- Sampling plans
- Correlation and regression
- Analysis of variance
- Design of experiments methodology
- Optimisation by response surface methodology

The examples studied will be based on industrial, economic or scientific practices and will enable students to learn how to use various types of software.

Mathematics and Cryptography

Department: *Mathematics-Computer Science*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7*

Duration: *32h*

Organisation: *Six 4h sessions.*

Assessment: *1 test + 1 lab session + unsupervised work*

Specific rooms: *Computer lab (lab session)*

Prerequisites:

Lecturer(s): F. Semet, A. Toguyeni

Objectives:

Knowledge / Skills:

- understand the basic arithmetic concepts of cryptography.
- choose and/or design a cryptographic algorithm for a given situation.

Module content summary:

Number theory in cryptography: the Chinese remainder theorem.

Extended Euclidean algorithm, Fermat-Euler theorem, quadratic residues, whole-number factorisation problems.

Complexity theory approach, Merkle-Hellman algorithm. Affine encoding, Vigenère encryption. Encryption, decryption and key signature (public and private) algorithms. RSA example.

Attack procedures, Miller-Rabin algorithm.

Algorithmic implementation.

Application aspects: protocols, networks and security features.

Wavelets and their Applications

Department: *Mathematics & Computer Science*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32h*

Organisation: *12h lectures / 12h supervised lab sessions / 8h unsupervised lab sessions*

Assessment: *75% lab work + 25% exam*

Specific rooms: *C016*

Prerequisites: *Fourier analysis, sampling theory, dot product of functions, Matlab basics*

Lecturer(s): P. Chainais

Objectives.

Knowledge

Basics of time-frequency analysis and time-scale analysis; theory of wavelets

Skills

Implementation of time-frequency analysis and wavelet analysis (algorithms), denoising, signal and image compression, singularity detection, etc. Lab work will be carried out using Matlab.

Module Content Summary.

This module is an introduction to the theory of wavelets and their practical applications. It is an opportunity to study a recent mathematical tool that emerged in the mid-1980s. The module also focuses on wavelet applications pertaining to audio signals and images from a practical point of view.

After a quick revision of Fourier analysis, we will study the theoretical basics of time-frequency analysis, with particular emphasis on the short-time (window) Fourier transform. This is an important step in the analysis of wavelets. We will begin by considering the continuous wavelet transform and its numerical implementation. We will compare the advantages and limitations of the different approaches (window Fourier vs. wavelet) in relation to the intended application. We will then study the orthogonal wavelet transform and its numerical 1D and 2D implementation. Mallat's recursive algorithm will be introduced.

Most of the concepts covered in the module will be put into practice during lab sessions (Matlab) in order to establish the link between the most theoretical aspects and their algorithmic expression. We will implement the window Fourier transform and learn to read and use a spectrogram. The application to sound denoising will serve as an audio example. We will then implement the continuous wavelet transform and compare the information obtained - the scalogram - with the spectrogram. We will also discuss singularity detection. We will programme the rapid recursive algorithm for orthogonal wavelet transforms in 1D. We will then consider mainly image processing applications (2D). A lab session will allow students to familiarise themselves with the 2D Fourier transform before proceeding to the 2D local cosine transform and the 2D wavelet transform. Applications to denoising and image compression will be studied. We will also cover texture synthesis and image restoration (inpainting), possibly by studying a scientific paper.

Curricular Harmonisation in Control Engineering

Department: *EEA*

Year: *G1*

Category: *Curricular harmonisation*

Semester: *S5*

Duration: *16h*

Organisation: *Tutorials*

Four 4h seminars

Assessment: *none*

Room/Materials: *none*

Prerequisites: *Laplace Transform*

Lecturer(s): C. Sueur, G. Dauphin-Tanguy, P. Borne

Objectives.

Refresher course in Control Engineering (SPI)

Knowledge:

The modelling, analysis and control of processes are part and parcel of an engineer's job, regardless of the technical or non-technical areas involved. This module has been designed to provide students with the necessary tools and methodologies for understanding, studying and controlling evolving processes. Various techniques of control synthesis by continuous controllers will be presented.

Skills:

Model a physical system. Draw up a specifications sheet for controlling the physical system. Design a controller according to the specifications. Analyse the performance of the controlled system.

Module Content Summary.

- Concepts of modelling and identification. Calculating transfer functions.
- Time response of linear systems.
- Frequency response: locus plots (Bode, Nyquist, Black).
- Concept of stability: Routh, Nyquist criteria.
- Concept of controlled system.
- Control synthesis: precision, speed and stability criteria.
- Study of controllers: Proportional, Proportional-Integral (PI) and Lag-Lead Compensator (LLC).
- Example of control of physical systems.

Curricular Harmonisation in Electrical Engineering

Department: *EEA*

Year: *G1*

Category: *Curricular harmonisation*

Semester: *S5*

Duration: *16 h*

Organisation: *Lectures, tutorials*

Assessment: *none*

Room/Materials: *none*

Prerequisites: *none*

Lecturer(s): P. Le Moigne (lecturer-in-charge), M. Hecquet, X. Guillaud, X. Margueron

Objectives.

Refresher course in SPI Electrical Engineering (Year 2 PSI physics classes)

Knowledge:

Application of ferromagnetism, hysteresis loop, inductance, ideal transformer

Ideal chopper, principle of operation of a DC motor

Speed control of a DC motor

Skills:

Understand the principle of operation of an electric power transmission chain

Module Content Summary.

Static electromagnetic conversion:

- ideal induction coil
- coupling 2 induction coils, perfect transformer
- ferromagnetism and its applications: hysteresis loop

Electromechanical conversion:

- parts and principle of operation of a DC motor
- application to speed control of a DC motor

Static converters:

- ideal sources
- perfect Diode/Transistor commutation cell
- step-down, step-up and current-reversible choppers

Signal Processing

Department: *EEA*

Year: *G1*

Category: *Core curriculum*

Semester: *S6*

Duration: *2h*

Organisation: *8h lectures / 10h tutorials / 12h lab sessions*

Assessment: *2h test (lab attendance compulsory)*

Specific rooms: *Lab session in rooms C112 – C116 / C212*

Prerequisites:

Lecturer(s): Ph. Vanheeghe (lecturer-in-charge) - M. Goueygou - J. C. Tricot- Ph. Pernod - E. Duflos - B. Piwakowski - N. Tiercelin - Y. Dusch - A. Rabaoui – S. Hage-Ali

Objectives.

Knowledge:

Main models used in the representation of signals. The fundamental principles of digital signal processing will be covered, especially the principles of operation of digital filters as well as their design and construction. Concept of random signal processing and estimation.

Skills:

Characterise a signal. Master the fundamental concepts of digital signal processing and random signal processing.

Module content summary.

- Signal processing
- Deterministic analogue signals
- Digital signals
- Discrete Fourier Transform
- Z-transform
- Digital filtering
- Finite impulse response (FIR) filter
- Infinite impulse response (IIR) filter
- Introduction to random signal processing

Electrical Networks and Electronic Energy Conversion

Department: *EEA*

Year: *G1*

Category: *Core curriculum*

Semester: *S5*

Duration: *32h*

Organisation: *6h lectures / 6h tutorials / 8h lab sessions / 10h PBL*

Assessment: *2h test at the end of the module (lab attendance compulsory)*

Specific rooms: *Lab session in Room C027*

Prerequisites:

Lecturer(s): P. Le Moigne (in charge of power electronics part of module) - S. Brisset (in charge of PBL) – F. Gillon – M. Hecquet – X. Margueron – E. Delmotte - X. Guillaud

Objectives.

Knowledge:

- Apply the power assessment method and the vector diagram method to calculate power factor, currents and voltages in a single-phase or balanced three-phase circuit.
- Draw up a diagram corresponding to a balanced three-phase circuit and specify the elements' impedances, the voltages, currents and powers.
- Use measuring devices (voltmeter, ammeter, wattmeter), design and build circuitry, compare measurements with theoretical calculations and explain the differences.

- Name the different categories of static converters and explain the different operating phases of a chopper and a single-phase diode rectifier.
- Identify and calculate the different types of losses in switches and their causes, and calculate the efficiency of a converter.
- Explain and apply the principle of alternating sources for fully controlled converters.
- Know the structures of direct choppers (series, parallel, reversible, bridge) and how to analyse their operation.
- Understand how single-phase diode rectifiers work.

Skills:

Master the different methods used in the theory of electrical networks as well as the categories of static converters; Know how to build a three-phase circuit with measurements of power, current and voltage, and determine the corresponding diagram. Know the basic principles of Power Electronics (kinds of sources, commutation cells, etc.). Know how to apply them to direct choppers and single-phase diode rectifiers.

Module Content Summary.

- Balanced three-phase circuits (PBL): general laws, power assessment and vector diagram, corresponding diagram.
- Power Electronics: General concepts, applications to choppers and single-phase diode rectifiers

Electromechanical Conversion and Speed Control

Department: *EEA*

Year: *G1*

Category: *Core curriculum*

Semester: *S6*

Duration: *32h*

Organisation: *10h lectures / 10h tutorials / 4h lab sessions*

Assessment: *2h test (lab attendance compulsory)*

Specific rooms: *Lab session in Room C027*

Prerequisites:

Lecturer(s): F. Gillon (lecturer-in-charge)
M. Hecquet – S. Brisset – X. Guillaud – P. Le Moigne

Objectives.

Knowledge:

At the end of this module, students will know how to do the following:

- Explain the context of electromechanical conversion and its applications
- Identify the main laws of electromagnetism that are of use in electric motors
- Apply the energy approach and carry out a power assessment
- Identify and prove the existence of a rotating field
- Explain the principle of operation of synchronous motors and recognise a synchronous motor
- Explain the structure of the electric model of a synchronous motor in relation to the physical phenomena that occur within it
- Draw a Fresnel diagram of a synchronous motor
- Calculate the energy efficiency and the performance of a motor and an alternator for various applications: electric traction and network coupling
- Define the control strategies at maximum torque and overdrive
- Explain how a three-phase bridge works, the purpose of PWM, and describe DC/AC conversion
- Explain the energy vision for converters and calculate the losses in a three-phase inverter

Skills:

Master the ability to identify a synchronous motor as well as its output characteristics: torque, efficiency. Master the operating principle of the combination of a motor and a variable-frequency drive.

Module Content Summary.

- Magnetic circuits and energy vision
- Principle of the rotating field and implementation
- Build an electric model equivalent to the synchronous motor
- Applications to the production of electricity and electric traction
- Power supply of variable-frequency three-phase motors – the three-phase inverter

Electronic Systems

Department: *EEA*

Year: *G2*

Category: *Core curriculum*

Semester: *S7*

Duration: *32h*

Organisation: *15 h seminars-lectures-tutorials / 16h seminars-lectures-lab sessions*

Assessment: *1h test (lab attendance compulsory)*

Specific rooms: *Lab session in Rooms C204 - 206*

Prerequisites:

Lecturer(s): O. Bou Matar - Lacaze (lecturer-in-charge), M. Goueygou, P. Pernod, B. Piwakowski, C. Sion, A. Talbi

Objectives.

Knowledge:

- Know the main functions of analogue electronics.
- For each of these functions, know the most common principles of construction.

Skills:

- Know how to spot the main functions in a complex electronic circuit diagram.
- Be able to determine the purpose of a circuit based on its electronic circuit diagram.
- Know how to draw up specifications for building an analogue electronic system.

Module Content Summary.

- Introduction, GSM example of the main functions of analogue electronics.
- Voltage amplification and power amplification.
- Filtering.
- Signal generation.
- Frequency synthesis.
- Data transmission function and return to GSM example.
- Recap exercises.

Control Engineering

Department: *EEA*

Year: *G2*

Category: *Core curriculum*

Semester: *S7*

Duration: *32h*

Organisation: *8h lectures / 10h tutorials / 12h lab sessions*

Assessment: *2h test and continuous assessment (compulsory lab and tutorial attendance)*

Specific rooms: *Lab sessions in Rooms C112 – C116 / C014*

Prerequisites: *Control of Continuous Systems – Laplace Transforms – Loci*

Lecturer(s): *C. Sueur (lecturer-in-charge) - G. Dauphin-Tanguy - A. El Kamel - A. Kruszewski*

Objectives.

Knowledge:

The modelling, analysis and control of processes are part and parcel of an engineer's job, regardless of the technical or non-technical areas involved. This module has been designed to provide students with the necessary tools and methodologies for understanding and studying evolving processes. The use of digital computers will make it easier to control industrial and non-industrial processes alike, and enable the illustration of theoretical concepts presented during the lectures and tutorials.

Skills:

Master the digital control of dynamic systems, from analysis to synthesis, by means of various approaches (PID, RST method, state-space representation) and know how to draw up the relevant specifications.

Module Content Summary.

Revision of the concepts of process and control, continuous signals, transfer functions, state-space representation of continuous systems, stability of linear continuous systems, concepts of controllability, observability, precision, generating continuous control.

Introduction to digital control: sampled signals, z-transfer functions. State-space representations. Stability of linear sampled systems. Precision, controllability, observability. Digital control: continuous methods, digital PID. RST control. State-space control. State-space reconstruction.

Sensors and Actuators

Department: *EEA*

Year: *G1*

Category: *Discipline-based elective module*

Semester: *S6*

Duration: *32 h*

Organisation: *Case studies during lectures, tutorials and lab sessions*

Unsupervised work: 8 h – Micro-projects on several specific sensors

Assessment: *Lab work and micro-project presentation*

Room/Materials: *Constraints related to the use of a lab (C206)*

Prerequisites: *Solid-State Physics – Signal Processing*

Lecturer(s): J-C. Tricot (lecturer-in-charge), O. Bou Matar, A. Talbi

Objectives.

Access to data and measurements is a vital feature in the relationship between knowledge and reality. In this regard, nothing can be achieved without **sensors**, which constitute the basis of all measurements. Whether we seek to save energy, respect the environment, improve working conditions or product quality, increase comfort levels or safety standards, proper measurement and control instrumentation are essential. For each quantity that must be measured and controlled, many physical principles and environmental and implementation conditions come into play. There are thus a multitude of products available, and knowing how to choose the right sensor is no easy task.

Another fascinating area of this module involves the introduction of technologies based on microelectronics and micromechanics: micro- and nanotechnologies, on which many researchers have placed great hopes. It is one of the latest strong trends that includes applications in various fields such as the medical, environmental, car, aeronautical and chemical analysis sectors, just to name a few. These days, microelectromechanical systems or **MEMS** (microsensors, microactuators and microgenerators) are everywhere: Airbag acceleration sensors, ABS motion sensors, navigation gyros, combined motion-acceleration-rotation systems for Playstation® gamepads, inkjet printheads, micromirrors for digital projectors and micro fuel cells are just a few examples of complex microsystems that incorporate electronic, mechanical, optical and/or fluid functions within a single chip.

The latest developments have led to the concept of **intelligent sensors and microsensors**. These are truly miniaturised systems containing a set of functions that make them ever-increasingly autonomous within what can be an extremely small space. When combined with a miniaturised wireless and networked communications system, intelligent sensors can communicate with each other in various detection, analysis and monitoring applications. When equipped with a decision-making element that uses artificial intelligence techniques, they are capable of producing, receiving and handling data in symbolic form. These **symbolic sensors** (e.g. **fuzzy sensors**) are capable of reprocessing data that is initially poorly defined.

Knowledge:

Sensors - the key to measurements. Knowledge of the various sensors and conditioners implemented in industrial processes. Miniaturisation and integration - state of the art. Intelligent sensors and symbolic sensors.

Skills:

Draw up and/or meet specifications by identifying the desired functions and the constraints that must be taken into account.

Module Content Summary.

- Introduction – Definitions
- Economic aspects: established markets and emerging markets
- General principles of sensors, actuators and generators
- Design of a measuring chain (interfacing of sensors, actuators and generators)
- Industrial sensors
- The contribution of micro- and nanotechnologies
- Micro- and nano-actuators
- Multisensor systems: diagnosis and fusion
- Experiments

Automation of Systems

Department: *EEA*

Year: *G1*

Category: *Discipline-based elective module*

Semester: *S6*

Duration: *32 h*

Organisation: *Series of 4h seminars totalling 24 h + 8h project (unsupervised work)*

Assessment: *Project assessment*

Specific rooms: *Room C114 – materials: programmable components (combinatory and sequential logic) + PC and Festo unit and Room C118 – systems room*

Prerequisites: *None (usual post-preparatory class standard)*

Lecturer(s): *A. Kruszewski (lecturer-in-charge) and C. Sueur (lecturer-in-charge)*

Objectives.

Nowadays, many systems are designed to function autonomously. This implies the implementation of operating modes based on precise rules and appropriate equipment. The aim of this module is to teach students how to create an automated system while taking into account all the relevant constraints (material, environmental, safety, etc.).

Knowledge:

Combinatory logic, synchronous and asynchronous sequential logic, automation, safety.

Skills:

Be able to build sequential logic machines, programme robots, manage an automated unit with consideration of various constraints (material, environmental, safety, etc.).

Module Content Summary.

- Introduction to synchronous logic machines (4h). Building sequential logic machines. Experiment: building a traffic light.
- Introduction to Grafcet programmable robots (4h). Basic rules in Grafcet, creating basic Grafcets in PL7. Experiment: Automating a sorting or climbing robot.
- Advanced Grafcet (8h). Managing modes and safety, communication between robots, parallelism, synchronisation. Experiment: Managing an automated unit (flexible unit).
- Grafcet: Grafcet programming with a microcontroller (4h). Experiment: Managing a process with Lego Mindstorm.
- Recap and summary (4h): Programming a robot: the exercise allows students to apply every concept learned in the module. Project assessment.

Project: Automating the FESTO sorting unit.

Lighting and Energy Efficiency

Department: *EEA*

Year: *G1*

Category: *Discipline-based elective module*

Semester: *S6*

Duration: *32 h*

Organisation: *24h (lectures, tutorials, lab sessions) + 8h project (unsupervised work)*

Assessment: *Lab work, unsupervised work, MCQ*

Specific rooms: *Room 027*

Prerequisites: *Module 1 of core curriculum Electrical Engineering*

Lecturer(s): X. Margueron (lecturer-in-charge), P. Le Moigne (lecturer-in-charge) and Electrical Engineering lecturers.

Objectives.

Knowledge:

Introduction to lighting: basics of photometry, lighting quality criteria, energy efficiency criteria.

Know the main categories of lamps as well as their power supplies:

- Lamps and energy efficiency: incandescent lamps, low and high pressure discharge lamps, high-power LEDs,
- role and choice of power supply: dimmer, ballast-type power supply, electronic power supply, LED power supply,

Know the different procedures for light intensity adjustment and power factor correction (PFC).

Skills:

- be able to choose a power supply based on lighting criteria (type of lighting, electrical and energy constraints): improving the network power factor, efficiency, adjusting luminosity levels, etc.
- be able to draw up a lighting system
- learn and understand how electronic power supplies of lamps work (chopper, switch-mode power supply, resonant inverter, etc.)
- use a simulation software (PSIM) specifically designed for electrical systems
- use the DIALUX software for designing lighting systems (unsupervised work)
- Experimental work

Module Content Summary.

The aim of this elective module is to present the main categories of high-efficiency lighting on the market, as well as to show the basics of designing a lighting system. This will reveal the major role of Power Electronics in the operation of such devices. Indeed, the use of incandescent lighting, which has been the main source of lighting for many decades, is on the wane and is increasingly being replaced by solutions that are more complex but also much more energy efficient. The current challenge is to further develop these new sources so as to obtain a lighting quality that is comparable to that of incandescent lamps.

Photovoltaics

Department: *EEA*

Year: *G1*

Category: *Discipline-based elective module*

Semester: *S6*

Duration: *32 h*

Organisation: *24h (lectures, tutorials, lab sessions) + 8h project (unsupervised work)*

Assessment: *Lab work, case study, test/MCQ*

Specific rooms: *Room C212, Room C027*

Prerequisites: *Module 1 of core curriculum Electrical Engineering*

Lecturer(s): X. Margueron (lecturer-in-charge), Ph. Le Moigne (lecturer-in-charge), X. Guillaud, B. François, P. Bartholomeus

Context

The climate challenges of the 21st century have given rise to a growing interest in renewable energy sources. The use of photovoltaics appears to be a very attractive solution with a strong potential for development.

This module is intended as an introduction to photovoltaics and covers diverse aspects, from the description of the photovoltaic effect to the "system" aspect (panels – converters – storage), both in the presence and absence of a power grid connection.

Learning objectives.

Knowledge:

- Define the photovoltaic effect and its electrical modelling
- List the different panel technologies and explain their main characteristics
- Explain the special features of stand-alone or grid-connected systems
- Explain the operating principle of static converters used in photovoltaic systems (chopper, single-phase inverter) as well as the associated control systems (MPPT, etc.)
- List the different battery technologies
- Describe the compliance obligations for grid connections based on current standards

Skills:

- Use experimental methods for characterising photovoltaic cells
- Calculate the cost of a photovoltaic system
- Build a conversion chain in PSIM: Simulation of single-phase chopper(s)/inverter(s)
- Choose a battery according to the application
- Design a complete system according to a given set of specifications

Module Content Summary.

The aim of this elective module is to introduce students to photovoltaics in terms of components, systems and applications. After a brief overview, "From technology to the market", emphasis will be placed on the environment that enables proper functioning of solar panels. The basic structures for energy conversion (Power Electronics) will be analysed and simulated (PSIM software), and the associated control systems (MPPT, grid connection) will also be studied in terms of theory and via simulations. The particular characteristics of grid-connected and stand-alone photovoltaics (purpose and storage impact) will also be covered.

In terms of practical work, a lab session will allow students to use a solar bench to characterise panels and get acquainted with the concept of modelling. A site visit (ENSAM, solar platform, etc.) is usually scheduled. Finally, the PVsyst software will be used to study the photovoltaic potential of various buildings (homes, farms, multimedia libraries, etc.) and to carry out costings.

CAD for Electronic Systems

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7-A*

Duration: *32 h*

Organisation: *22h seminars and lab sessions + 10h unsupervised work*

Assessment: *Lab work*

Room/Materials: *Computer Lab C212 / Lab C206.*

Prerequisites: *Preparatory class in analogue electronics*

Lecturers: Cathy Sion (lecturer-in-charge), Olivier Bou Matar, Emmanuel Delmotte, Abdelkrim Talbi

Objective.

Today, electronic systems, which are found in many industrial sectors, are becoming increasingly complex. The aim of this elective module, **which places a particularly strong emphasis on practical applications**, is to **introduce students to the fundamental basics of CAD for complex electronic systems** that can contain a combination of analogue and digital functions, and teach them how to use software environments for designing, simulating and building mixed (analogue/digital) electronics systems.

Knowledge:

This elective module will, among other things, teach students how to interpret manufacturers' documentation for electronic components, combine components to achieve specific functions, and use a professional tool for designing, simulating and building an electronic board.

Skills:

This elective module is intended for students who wish to further their knowledge of mixed (analogue/digital) electronic systems and those who need to learn how to build electronic boards for their project.

Module Content Summary.

The main objective of this elective module is to analyse the general operation of a complex electronic circuit, e.g. one from an issue of Elektor magazine. This theoretical analysis will involve the study of electronic functions that students would already have encountered in their preparatory class years as well as technical documentation on the components. Examples of such a circuit include a light organ, an anti-theft display stand, a luminous voltmeter or a remote control. After examining the constituent functions of the circuit, students will simulate and optimise the system using the National Instruments Multisim software, which will enable the accurate design and sizing of the circuit's electronic functions. Next, students will use the Eagles software to build the phototool of the electronic board (*positioning and routing*) followed by the electronic board itself (*piercing, soldering of components to be inserted, SMD components, etc.*), with the help of the electronics workshop's state-of-the-art equipment and expertise. After carrying out unit testing and acceptance testing to check that the board works properly, students will conduct experimental measurements on the board in order to compare them with theoretical and simulation values.

Industrial Computer Systems

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7-A*

Duration: *32 h*

Organisation: *24h seminars + 8h project work, unsupervised + 8h unsupervised work*

Assessment: *Continuous assessment + project report*

Specific rooms: *Room C306*

Lecturer(s): *C. Vercauter (lecturer-in-charge)*

Objectives.

Knowledge:

This module covers the software and hardware architecture of distributed control systems incorporating various types of processors in a distributed environment: microcontrollers, DSP, real-time embedded and executive systems. Such systems rely on many different communication mechanisms and field networks that will be covered in this module: SPI, I2C, USB, CAN and ETHERNET. The design of a user interface for a control centre will be carried out in LABVIEW.

Skills:

Use various software development chains for microcontrollers (C167, PIC18, DsPIC, PIC32 and ARM).

Develop real-time applications based on interrupt processing and the use of executive or real-time OS services (OSEK, μ CLinux, RTLinux, etc.).

Applications in control engineering (e.g. speed control in electric motor), automation (e.g. managing a set of lifts), robotics (e.g. controlling a mobile robot, communication between robots and base station) and computing (building a TCP/IP – CAN gateway).

Module Content Summary.

- Software and hardware architecture of control systems.
- Communication bus and field networks.
- Real-time executive and operating systems.
- Development of a user interface and control using LABVIEW.
- Applications in the form of a mini-project.

Dynamic Modelling and Simulation of Multiphysics Systems

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7-A*

Duration: *32 h*

Organisation: *8h lectures / 4h tutorials / 8h lab sessions / 2h supervised project + 2h presentation + 8h unsupervised work*

Assessment: *1 individual test (30 min)*

1 case study (report and oral presentation) in groups of three

Specific rooms: *Lab session in Room C016*

Prerequisites: *None (usual post-preparatory class standard)*

Lecturer(s): G. Dauphin-Tanguy (lecturer-in-charge), X. Guillaud, S. Paul, P. Dupont, C. Sueur, A. Dazin (ENSAM).

Context.

In the current competitive economic climate, businesses are forced to become more and more innovative, responsive and close to the market. In a bid to reduce the design time of innovative products and improve existing products, businesses seek ways to capitalise on their expertise using model libraries and implement new organisational structures. Project team members specialise in a variety of disciplines (mechanics, hydraulics, thermodynamics, electrotechnics, automation, electronics, etc.) and work together to develop "integrated designs" that encompass all the inherent aspects of a project, namely modelling, actuator design and sizing, control, reliability and prototyping.

The crux of the problem is to choose the most suitable modelling and simulation tool that will meet the following specifications:

- it must facilitate communication and the exchange of data and models between specialists from many different fields of physics,
- it must be applicable to all the design stages and cater to all energy concerns,
- it must lead to a dynamic model that is close enough to physical reality for it to be used as a "virtual" test bench that will enable the testing of control laws and the behaviour in fail-soft mode.

Many businesses in France and across the globe choose to use the bond graph tool because of its ability to meet these criteria. Some examples are:

- all the car manufacturers (PSA, Renault, Ford, Toyota, etc.) and their components manufacturers (Valeo, Siemens, Bosch, etc.)
- EADS with Airbus and Astrium ST
- EDF, Alstom, CEA, etc.

Objectives.

Knowledge:

- Increase students' awareness of the problems related to the design of complex systems that encompass various fields of physics and several types of energy.
- Introduce the principles of dynamic modelling (domain of validity of a model, causality) and simulation (solver, objectives, results analysis).

Skills:

- Know how to propose – with the aid of analogous concepts between various fields of physics – a "generic" dynamic modelling approach based on energy considerations.

Module Content Summary.

- Methodology and implementation in a few examples: 8h lectures (GD)/4h tutorials (GD)
- Learning and implementation with 20sim software: Two 4h lab sessions (GD)
- Case studies in various fields of application: 2h supervised work (XG/SP/CS/AD/GD) followed by 8h self-study
- 2h oral presentation on case studies (XG/SP/CS/AD/GD)
8 case studies have been planned: X. Guillaud, S. Paul, A. Dazin, C. Sueur, G. Dauphin

Force Feedback Interfaces and Virtual Reality

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7-B*

Duration: *32 h*

Organisation: *Series of seminars/lab sessions*

Assessment: *Assessment in the form of a project covering the most essential aspects of the module.*

Specific rooms: *Room C116*

Prerequisites: *Newtonian Mechanics, C Language.*

Lecturer(s): Alexandre Kruszewski (lecturer-in-charge) - Abdelkader El Kamel

Objectives.

Knowledge:

Know the different architectures for virtual reality applications, the different techniques used in the simulation of physical phenomena, the principle of 3D image display and the techniques used for haptic rendering and force estimation.

Skills:

Programme a display engine in OPENGL.

Control a haptic interface.

Create a physics simulation engine with collision detection.

Module Content Summary.

Introduction to force feedback control and virtual reality. The module focuses on a case study that will allow students to understand how a haptic interface works, learn how to handle the transmission of forces to the user, create a virtual environment and handle interactions between the latter and the user.

The module takes the form of a practical case study.

A visit to IRCICA and a talk given by researchers working in the field have been planned (4h).

Examples of materials:

Interface Phantom (SensAble), Matlab, etc.

Robotics Games

Department: EEA

Year: G2

Category: *Discipline-based elective module*

Semester: S7-B

Duration: 32 h

Organisation: *32h lectures/seminars/project (including 8h unsupervised work)*

Assessment: *Dependent on achievement of objectives and competition results*

Specific rooms: *Room C016 / Robotics Lab*

Prerequisites: *No prerequisites*

Lecturer: Abdelkader EL KAMEL (lecturer-in-charge).

Objectives:

Knowledge:

Know the different types of mobile robots. Know the basic concepts (kinematics and dynamics) involved in modelling a mobile robot. Concepts in planning, location and obstacle detection. Mobile robot programming.

Skills:

Operate a mobile robot with consideration of its environment (static or dynamic obstacles).

Module content summary:

Several years ago, as part of our activities in robotics, we started a robotics association at the Ecole Centrale de Lille. The aim of this association is to enable students to develop robotics applications and participate in the E=M6 Competition. We have participated about ten times as part of the G1-G2 project component and have succeeded in reaching the semi-finals.

In this module, students will be introduced to robotics in a fun manner that calls on their creativity and practicality. They will participate in a robotics competition involving games based on LEGO boxes and a set of accompanying sensors/actuators (CmuCam, RFID, etc.):

- Case studies on mobile robotics (Overview)
- From physical reality to Virtual and/or Augmented Reality in Mobile Robotics
- Competition organisation:
 - o Definition of annual theme
 - o Specification of robot functionalities
 - o Robot design in teams
 - o Development of appropriate strategies
 - o Operation – Tests – Optimisation
 - o Competition – Assessment – Ranking
- Feedback
- Possible future developments?

Distribution of Electrical Energy

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7-A*

Duration: *32 h*

Organisation: *Series of seminars / lab sessions / industrial talks + 8h unsupervised work*

Assessment: *MCQ + end-of-module report*

Specific rooms: *Rooms C212 / C027*

Prerequisites: *Module 1 of core curriculum Electrical Engineering*

Lecturer(s): X. Guillaud (lecturer-in-charge), X. Margueron, B. François, industry guest speakers

Industrial partners: EDF Recherche Développement - ERDF Electricité Réseau Distribution France -

RTE: Réseau de Transport d'Electricité

Context:

In recent years, power grids have undergone profound changes, triggered by the liberalisation of the energy sector as well as the ever-increasing incorporation of renewable energy sources. Grids are constantly evolving to contribute towards sustainable energy provision.

Objectives.

Knowledge:

- Describe the overall architecture of a power grid and its key elements.
- Explain how a three-phase transformer works and calculate the components of the equivalent model.
- Design and dimension a low-voltage electricity distribution network (neighbourhood transformer, lines, etc.).
- Identify and design the various safety features.

Skills:

- Determine the different parties involved in electricity distribution (producers, marketers, traders, distributors, transporters, consumers, etc.).
- Understand the future impact of ICT on the operation of grids (load control, intelligent meter, automatic grid reconfiguration).

Module Content Summary.

This module is designed to be an introduction to power grids. It begins with a study of the needs of users, then progressively introduces the main elements of a grid: production, architecture (transport, distribution), safety features, etc.

The key principles of system regulation will be covered: production-consumption balance, voltage control.

We will study the operation of mid-voltage electricity distribution networks in greater detail, and see how using Information and Communication Technologies (ICT) can contribute towards improving a system's overall energy efficiency and facilitate the incorporation of renewable energy sources.

This will give an idea of future changes that will pave the way for more "intelligent" power grids.

"Mainstream" Electric Actuators

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7-B2*

Duration: *32 h*

Organisation: *24h seminars (four 8h mini-projects) + 8h unsupervised work*

Assessment: *Lab work, individual test*

Specific rooms: *C018 – C027 – C206*

Prerequisites: *Module 2 of Electrical Engineering "Electromechanical Conversion and Speed Control"*

Lecturer(s): M. Hecquet (lecturer-in-charge), E. Delmotte, N. Bracikowski, L. Chalal.

Objectives:

Knowledge:

- operating principles of brushless and stepper motors
- electronic power supply of these two devices and the associated sensors
- principle of the control and power supply of DC motors
- reversibility of electromechanical systems
- open-loop control of stepper motors
- speed and position control of self-controlled synchronous motors (permanent-magnet or brushless DC).

Three types of motors will be presented: a DC motor and the accompanying electronics, a stepper motor and a BDC motor. A simulation tool will be presented, then used to validate the characteristics obtained.

Skills:

- Familiarisation with a power supply and motor control system (example of a brushless motor with experimental part based on a "mainstream" component: PIC microcontroller + integrated inverter)
- Recognise types of motor systems, motors and power supplies, and know how they work.
- Simulate a speed control system in PSIM.

Module Content Summary.

In this module, we will compare the different motor solutions for low-power applications (home applications) by examining the major solutions for speed and position control. Solutions that involve the use of DC motors, synchronous motors and stepper motors will be studied in terms of their operating principle, choice of motor, electronic power supply and control system (closed-loop speed control with torque control, open-loop position control, etc.).

Audible Acoustics - Noise and Vibrations

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *Four 2h lectures, three 4h tutorials, 4h oral presentation: 24h + 8h unsupervised work*

Assessment: *Oral presentation for a case study proposed by an industrial partner*

Rooms/Materials: *Constraints related to the use of labs and computer labs*

Prerequisites: *Signal Processing, Physics of Waves*

Lecturer(s): M. Goueygou (lecturer-in-charge), J-C Tricot, B. Piwakowski, Z. Lafhaj.

Objectives.

The field of applications of Acoustics is vast and covers many disciplines such as musical acoustics, diagnosis, condition-based maintenance of rotating machines and psychoacoustics, just to name a few.

The unintended effects of noise are well known and range from simple inconvenience to more acute somatic forms (hearing loss, occupational deafness, etc.). Therefore, it is important to be able to characterise the things that generate, propagate and amplify noise in order to remedy such problems.

Knowledge:

After a brief revision of the principles of wave emission and propagation, we will study physiological acoustics and room acoustics. One part of the module will be devoted to the numerical simulation of vibrations. Case studies on modal analysis, diagnosis and predictive maintenance by vibration analysis will serve to synergise the theoretical and practical (and even normative) aspects of noise and vibrations, thereby preparing students for future engineering assignments.

Skills:

- Calculate the noise level in a free field and a reverberant field.
- Quantification of an acoustic field: difference between pressure and intensity levels.

This module is acknowledged by the French Acoustics Society (Société Française d'Acoustique) and is recognised nationally.

Module Content Summary.

- Revision of the principle of acoustic wave emission and propagation / Basics of physiological acoustics.
- Room acoustics, sound perception according to room properties, numerical modelling.
- Analysis and measurement of sound and noise, analysis and statistical estimation of sound levels, time-frequency analysis of speech.
- Modelling and measuring vibrations.
- Acoustic signal processing.

Control of Dynamic Systems

Department: EEA

Year: G2

Category: *Discipline-based elective module*

Semester: S8

Duration: 32 h

Organisation: 16h lectures + 16h applications (in lab) (including 8h unsupervised work)

Assessment: 1 mini-report on the application developed (see below)

Rooms/Materials: C112 and C116.

Constraints: *maximum 16 students*

Lecturers: A. Kruszewski (in charge of seminar held in lab), W. Perruquetti, J.P. Richard (in charge of module), C. Sueur, L. Belkoura (Lille 1), L. Hetel (CNRS).

Objectives:

Knowledge:

Know basic concepts: closed loop, output feedback/state feedback, stability, controllability, observability, flatness. Know several control and observation methods. Based on examples, be able to tell the difference between "simple" cases (linear, stationary, finite dimensions) and more complex situations (non-linear systems, hybrid systems, time-delay systems). Get acquainted with optimisation using Linear Matrix Inequalities (LMI).

Skills:

Apply the concepts and methods mentioned above, i.e. test the procedure for modelling and generating autonomous systems. Establish the link between: 1. a real system (see examples below) and objectives; 2. models, properties that can be formulated in a specifications sheet and control methods.

Module Content Summary.

Lectures will be based on concrete examples, which will be carried over into tutorials and lab sessions.		
7h lectures	Linear systems: state, structure, observation, control	(JPR)
3h lecture	Differential flatness: application to control	(CS)
3h lecture	Non-linear systems: examples of control problems	(WP)
3h lecture	LMI optimisation: a few applications in robust control	(LH)
16h lab work/ tutorials	Four 4h sessions, in groups of two	(AK)

The module is very much geared towards practical work. Each group chooses an application and develops it from start to finish (modelling, specifications, basic control, advanced control, overall assessment). Assessment will be based on lab work (mini-report to be handed in after the 16 hours).

The available platforms include: air-flow levitated marble, marble on track, Furuta pendulum, Lego crane, Lego mobile bridge with swing arm, Lego mobile robot, etc.

Examples of applications in 2010-2011: <http://chercheurs.lille.inria.fr/~jrichard/manips.htm>

Teaching schedule in S8:

Week 1	lesson 1	(JPR)	4H lecture
Week 2	lesson 2	(JPR)	3H lecture + 1 unsupervised work
Week 3	lesson 3	(CS or WP or LH)	3H lecture + 1 unsupervised work
Week 4	lesson 4	(CS or WP or LH)	3H lecture + 1 unsupervised work
Week 5	lesson 5	(CS or WP or LH)	3H lecture + 1 unsupervised work
Week 6	lab session 6	(AK)	3H tutorial + 1 unsupervised work
Week 7	lab session 7	(AK)	3H tutorial + 1 unsupervised work
Week 8	lab session 8	(AK)	3H tutorial + 1 unsupervised work
Week 9	lab session 9	(AK)	3H tutorial + 1 unsupervised work

Engineering of Complex Systems

Department: EEA

Year: G2

Category: *Discipline-based elective module*

Semester: S8

Duration: 32 h

Organisation: 3h MathWorks talk, 21h seminars / lab sessions + 8h unsupervised work

Assessment: Project (presentation on case study)

Specific rooms: Room C212

Prerequisites: No prerequisites

Lecturer(s): S. Brisset (lecturer-in-charge), M. Hecquet, F. Gillon

Objectives:

Knowledge:

- Diversity and structural design of MathWorks products.
- Matlab environment and its usefulness in matrix calculations, solving differential equations and non-linear differential equations, etc.
- Dynamic simulation techniques in Simulink.
- Multiphysics modules such as SimScape* (modelling and simulation of mechatronic systems and other multidisciplinary physical systems by means of a physical network).

Skills:

- Use Matlab for matrix calculations, visualisation, everyday engineering operations such as solving differential equations or a system of non-linear equations.
- Use Simulink to simulate dynamic systems.
- Use SIMscape to model an electromagnetic valve as a localised-constant system.

*Tool developed in a unique environment by combining Simscape with MathWorks physical modelling tools adapted for specific fields, e.g. SimElectronics™, SimMechanics™, SimDriveline™, SimHydraulics® and SimPowerSystems™.

Module Content Summary:

- MathWorks talk (3h)
- Overview of project (1h)
- Matlab for matrix and complex calculations, viewing results, solving systems of non-linear equations (4h)
- Matlab for solving differential equations and comparison with Simulink and Simscape approaches (2h)
- Localised-constant networks for multiphysics systems (2h)
- Simulink, SimScape, SimPowerSystems and SimMechanics for simulating mechatronic systems (4h)
- Simulation of a localised-constant network with SimScape (2h)

Project: Simulation of an electromagnetic valve with SimScape (14h)

New and Emerging Digital Technologies

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *20h seminars + 12h unsupervised work*
(Entire module takes place over 2 consecutive weeks)

Assessment: *individual test (creation of an application).*

Specific rooms: *C204 / C206 – C212*

Prerequisites: *None*

Lecturer(s): *C. Sion (lecturer-in-charge), E. Delmotte*

Objectives.

(Teaching through PBL)

Knowledge:

- Interpret the key operating mechanisms of objects that use new technologies;
- Understand the associated physical phenomena;
- Be aware of future standards and current limitations;
- Establish the link between technologies and the associated sciences. To do so, students will be provided with low-cost high-tech objects, e.g. solar lamps, DVD players and 3D glasses.

Skills:

At the end of this module, students will be able to understand and explain the various mainstream emerging digital technologies.

Module Content Summary.

Mainstream digital electronics constitute an ever-increasing part of our daily lives. Today, it is not uncommon for us to use many high-tech objects without knowing the technology behind them or how they work; nor are most people able to form an informed and critical opinion of the technical capabilities that are the main selling point of such products. Some of these new technologies include flat-panel displays (liquid crystal, plasma, OLED, etc.), touch screens (resistive and capacitive procedures), RFID tags, digital cameras (CCD sensors), digital camcorders, mobile phones, CD-DVD burners, SATNAV systems, storage and recording systems, etc.

The main aim of this elective module is to raise students' awareness of and interest in these new and emerging digital technologies that are now a part of their daily lives. The learning objectives are to understand the key operating mechanisms of objects that use new technologies and to establish the link between these technologies and the associated sciences. To do so, students will be provided with low-cost high-tech objects, such as solar lamps, DVD players and 3D glasses, which are to be taken apart, analysed and tested in order to discover how they work.

Intelligent Control of Embedded Systems

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *12h lectures/seminars: 20h case studies, of which 8h unsupervised work*

Assessment: *Continuous assessment and case studies*

Specific rooms: *C016 & microcomputer lab (C306)*

Prerequisites: *General Control Engineering – Sensors – Microcontrollers*

Lecturer(s): *A. El Kamel (lecturer-in-charge), C. Vercauter*

Objectives:

Knowledge:

The objective of this module is to train engineering students to use advanced digital tools in systems and control, and to teach them the context for their use, be it in real-time computer control or in a microcontroller-based embedded system. The module will cover many practical examples and applications, as well as practical case studies.

Skills:

Master the different tools and algorithms for real-time control of processes by means of PCs or microcontrollers.

Module Content:

Our relations with the Industry and Commerce Competitiveness Cluster (PICOM) have enabled us to evaluate the extent of the development of mobile applications based on the use of embedded and/or real-time technologies. In this context, we conducted a full study of an indoor guidance/navigation system, a kind of indoor GPS, implemented in a Smartphone using Android, which can be used in supermarkets to help customers, especially the disabled, to do their shopping. At the same time, we are involved in the Smart City project, whose aim is to design and develop applications for a more open city equipped with intelligent and mobile service applications.

The objective of this module is to teach engineering students about advanced digital tools in industrial data processing and how/when to use them in embedded systems. Many practical examples and applications will be given:

- Supplementary information on numerical process control
- Supplementary information on real-time constrained process optimisation
- Supplementary information on microcontrollers and embedded systems
- Presentation of input/output boards (RTI, DSP, RTW, xPC-Target, Embedded C-Coder, etc.): performance and limitations, impact on practical implementation
- ...
- Smart City case studies

Soft Computing and Metaheuristics for Optimisation and Decision Aid Systems

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *24h comprising 10h lectures, 6h tutorials & lab sessions, and 8h unsupervised work*

Assessment: *1 individual test at the end of the module*

Specific rooms: *Room with PC and MATLAB soft computing toolboxes for lab session, tutorials and unsupervised work*

Lecturer(s): P. Borne (lecturer-in-charge), M. Benrejeb, A. El Kamel

Objectives.

Know the different methodologies for optimisation and decision aid.

Knowledge:

Know the concepts pertaining to:

- fuzzy logic, fuzzy control, decision aid
- artificial neural networks, classification and optimisation
- the metaheuristics of optimisation
- multi-objective optimisation and Pareto optimality

Skills:

Master the different methodologies for use in optimisation and, more generally, in decision aid.

Module Content:

Fuzzy logic, fuzzy control, location classes, decision classes, inference engine, fuzzification, defuzzification. Mamdani's method and Takagi-Sugeno-Kang method.

Artificial neural networks: learning, key component analysis, classification, Hopfield network and optimisation.

Metaheuristics of optimisation: genetic algorithms and algorithms based on evolution strategy, ant colonies, particle swarm, simulated annealing, Tabu method, tunnelling.

Multi-objective optimisation and Pareto optimality.

Design and Control of Robotised Workshops

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *24h seminars & lab sessions (6 x 4h in AIP workshop) + 8h unsupervised work (over two consecutive weeks)*

Assessment: *individual test (creation of an application).*

Specific rooms: *AIP PRIMECA C302 Polytech'Lille*

Prerequisites: *None*

Lecturer(s): *A. Rahmani (lecturer-in-charge), O. Scrive.*

Objectives.

Knowledge:

Know the concepts involved in modelling, using, programming and building a robot. Various levels of control. Various programming levels. Know the structure of a flexible automated production workshop. Concepts pertaining to the instrumentation, use and control of an instrumented conveyer.

Skills:

Programming handling robots. Programming mobile robots. Identifying and analysing the different functionalities required for controlling a robot. Modelling, designing, simulating and building a production workshop.

Module Content Summary.

Key stages:

- Introduction to Robotics: general concepts of geometric models and dynamic models.
- Introduction to a few applications: teleoperation in robotics, medical robotics and virtual reality in robotics.
- Programming handling robots.
- Programming mobile robots.
- Controlling an instrumented conveyer.
- Integration: Model, design, simulate, build and control a production workshop according to a predefined production plan (project work in groups of 12 to 16 students).

This project work will be carried out in the AIP PRIMECA production workshop, which has all the necessary industrial equipment:

- Instrumented conveyer (sensors, actuators, cameras, etc.)
- Industrial handling robots (ABB and KUKA, 4, 6 and 7 axes)
- Mobile robots (Robotino)
- Tools: robot programming language (Delmia, Rapid, RobotStudio, PrograMaker, KukaSim).

Programmable Digital Electronics

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *10 h lectures + 12 h lab sessions + 10 h unsupervised work*

Assessment: *Lab report and mini-project*

Room/Materials: *Rooms with PC for lab sessions (C204, C206).*

Prerequisites: *Core curriculum "Electronic Systems"*

Lecturer(s): M. Goueygou (lecturer-in-charge), N. Tiercelin, A. Talbi, O. Bou Matar, E. Delmotte + 2 guest speakers from USTL

Context:

Today, all electronic systems are part analogue and part digital, with the latter accounting for an ever-increasing proportion of the constituents. One of the aims of this elective module is to complement the main electronics module by proposing an introduction to digital electronics, especially programmable components, which now constitute the core of most electronic systems. Since programmable components lie at the intersection between electronics, industrial computing and signal processing, these three fields will be covered while maintaining an electronics approach through the use of a professional FPGA environment for design, simulation and programming: Altera DE2 board programmed with the QUARTUS II software. VHDL programming will be taught during a tutorial. At the end of this elective module, students will be required to design and test a digital filter according to a set of specifications.

This module is for students who wish to further their knowledge of electronic systems and those who need to learn FPGA programming.

Objectives.

Knowledge:

- Overview of combinatory and sequential logic systems.
- Architecture of programmable components, especially FPGA ones.
- Architecture of basic logic functions.

Skills:

- VHDL programming.
- Creation of FIR and IIR digital filters.

Module Content Summary.

- Introduction to digital electronics: component technologies, programmable components, combinatory and sequential logic.
- Carry out a project according to a set of specifications:
 - Analysis of specifications;
 - Design & simulation;
 - FPGA programming;
 - Programme implementation in FPGA;
 - Full characterisation of the system created in order to check that it meets the specifications.

Subsurface Imaging

Department: EEA

Year: G2

Category: *Discipline-based elective module*

Semester: S8

Duration: 32 h

Organisation: 8 h lectures + seminars and practical work / 10h unsupervised work

Assessment: based on three components:

Oral presentation (pair work), 15 min with PowerPoint slides + 10 min discussion / Report on data processing / Lecture attendance

Specific rooms: PC lab (C212 or C018) + on-site practical work.

Prerequisites: Core curriculum "Electronic Systems" + core curriculum "Signal Processing"

Lecturers: B. Piwakowski + 2 guest speakers

Objectives.

The subject area of this module is one of the topical themes related to the environment and risk exposure. The potential applications lie mainly in the fields of civil engineering, risk exposure analysis (building permit), the detection and location of underground hollows, archaeological prospecting, problems related to the search for water sources, water pollution, subsurface pollution, the search for natural resources (petroleum, etc.), and so on. Imaging methods call for expertise in a wide range of disciplines: geophysics, electronics, signal processing, acoustic and electromagnetic wave propagation, principles of wave imaging, etc.

This module presents the principles of the most commonly used methods, i.e. electrical, electromagnetic and magnetic methods and geophysical radar, as well as seismic (acoustic) methods.

Teaching will not be confined to theory, but will involve practical work for applying seismic methods. During the practical session that will take place on campus, students will carry out real subsurface imaging measurements up to a depth of 100 m. The data recorded will then be processed by the students in order to obtain the image of the subsurface. All this will be made possible thanks to the laboratory's expertise, acquired over 20 years of research, and its state-of-the-art equipment, including all the necessary seismic data processing software.

Knowledge:

Know the most commonly used methods in subsurface imaging, i.e. electrical, electromagnetic and magnetic methods, geophysical radar, as well as seismic (acoustic) methods.

Skills:

Assess and dimension a subsurface imaging problem, choose the most appropriate method, know how to carry out measurements, process, analyse and interpret data.

Measurements to obtain subsurface images up to a depth of 100 m.

Application of seismic methods, data processing using appropriate software, interpretation of results.

Application of electrical methods (geophysical radar and electrical tomography).

Module Content Summary.

- 2x 4h lectures on subsurface imaging methods, principles, implementation, limitations, basic parameters. Examples of results and their interpretations.
- 1x 4h practical work on the Villeneuve d'Ascq campus, with the participation of Mr P. Dusautoy, head of the geophysical design and engineering department G-CO and use of its measurement equipment (geophysical radar, resistivity).
- 1x 4h practical work on acoustic (seismic) imaging, using equipment and carrying out on-campus data acquisition.
- 2x 4h Processing of data recorded on campus.
- 1x 4h talk by guest speaker.
- 1x 4h Unsupervised work, preparation of presentation.
- 1x 4h Seminar, student presentations

Speed Control applied to the Electric Vehicle

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *6h lectures / 2h tutorials / 16h lab work / 8h unsupervised work*

Assessment: *Continuous assessment (lab work) + project assessment.*

Specific rooms: *Rooms C212 / C027*

Prerequisites: *Modules 1 and 2 of core curriculum "Electrical Engineering"*

Lecturer(s): M. Hecquet (lecturer-in-charge) & F. Gillon (lecturer-in-charge).

Objectives.

Knowledge:

Context of the electric vehicle, energy aspects, understand the operating principle of an asynchronous motor, model an asynchronous motor.

Understand the principle of speed control in such a motor and the technology used for the variable-frequency drive. Energy modelling of the traction system (case of the electric go-kart).

Skills:

Use an electronic/mechanical model for the motor, identify the values of model parameters and build a numerical model of an electric motor by using computation software.

Know how to establish an electrical-mechanical conversion chain as a numerical model (energy aspect).

Know how to design and dimension the necessary components and define specifications.

Module Content Summary.

This module concerns the speed control of electric motors used in "electric vehicles". After an overview of the current developments in electric vehicles, we will examine the following points:

- How to vary speed?
- What are the different types of variable-frequency drives and their characteristics?
- How to model an asynchronous motor and the associated converter.
- Application to the case of an electric go-kart.

Machine Vision and Image Processing

Department: *EEA*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *24h (6 x 4h seminars, lectures, tutorials and integrated lab work: AIP workshop) + 8h unsupervised work*

Assessment: *individual test (creation of an application).*

Specific rooms: *AIP PRIMECA C302 Polytech'Lille*

Prerequisites: *None*

Lecturer(s): *A. Rahmani (lecturer-in-charge), O. Scrive.*

Objectives.

Knowledge:

Image processing: Segmentation and improvement techniques. Classic convolution operations. Mathematical morphology. Edge detection and filtering techniques.

Machine vision: image acquisition chain: choice of acquisition cameras and boards, lighting techniques.

Skills:

Design and build a machine vision device.

Build a machine vision application based on image processing functions.

Module Content Summary.

Key stages:

- Designing a machine vision device.
- Segmentation algorithms. Shape parameters.
- Logical smoothing of binary images. Histogram transformation and smoothing of greyscale images.
- Convolution and its application to edge extraction.
- Binary and greyscale mathematical morphology.
- Application: each group of students will be required to build a machine vision application in the fields of robotics, medicine, production, etc.

Teaching materials:

This module will be conducted on the AIP PRIMECA premises, which have all the necessary industrial facilities and equipment:

- Industrial cameras
- Lighting systems
- Acquisition boards
- Image processing software (Aphelion)

Department of Physical Sciences

Curricular Harmonisation in Fluid Mechanics

Department: *Physical Sciences*

Year: *G1*

Category: *Curricular harmonisation*

Semester: *S5*

Duration: *16 h*

Organisation: *Series of four 4h sessions.*

Assessment:

Specific rooms:

Prerequisites:

Lecturer(s): J.M. Foucaut, P. Dupont, M. Stanislas

Objectives.

- Know how to write up and solve equations in Fluid Statics.
- Know the principles of Fluid Kinematics.
- Know how to write up and solve equations in Dynamics of Ideal Fluids.

Module Content Summary.

- General introduction
- Fluid statics
 - Principle of hydrostatics
 - Archimedes' principle
 - Equilibrium of the atmosphere
- Fluid kinematics
 - Different points of view
 - Material derivative
- Dynamics of ideal fluids
 - Euler equations
 - Bernoulli's principle

Introduction to Solid-State Physics

Department: *Physical Sciences*

Year: *G1*

Category: *Core curriculum*

Semester: *S5*

Duration: *32h*

Organisation: *lectures and tutorials*

Assessment: *lab work and written exam*

Specific rooms: *electronics labs for lab work*

Prerequisites: *none (post-preparatory class standard)*

Lecturer(s): O. Bou Matar - Lacaze, M. Goueygou, P. Pernod, B. Piwakowski, C. Sion, A. Talbi, J.-C. Tricot

Objectives.

Knowledge:

- Know the various crystal lattice structures and their symmetry properties
- Know the origin of the main properties of solid-state materials (thermodynamic, electrical, optical, dielectric, magnetic, etc.)
- Know how these properties are put to use

Skills:

- Know how to choose a category of solid-state materials and the associated physical effects to solve real problems
- Know how to formalise the main physical effects associated with these solid-state materials and assess the orders of magnitude of their characteristic parameters, temperature dependence, electric and magnetic fields
- Know how to use solid-state materials to meet a set of specifications.

Module Content Summary.

- Condensed state, crystalline structures, reciprocal lattice
- Lattice dynamics (optical and acoustic phonons)
- Structure of energy bands, population distribution
- Classification of solids (metals, insulators, semi-conductors)
- Intrinsic and extrinsic semi-conductors, transport phenomena, Hall effect, junction, photovoltaic effect, Gunn effect, Peltier effect, transistor effect, field effect
- Dielectrics and ferroelectrics, optical properties of crystals
- Diamagnetism, paramagnetism, ordered magnetism
- Magnetic resonance, stimulated emission, spin waves
- Superconductivity, Josephson effect
- Applications

Transport Phenomena

Department: *Physical Sciences*

Year: *G1*

Category: *Core curriculum*

Semester: *S5*

Duration: *32 h*

Organisation: *Lectures, tutorials and seminars*

Assessment: *written exam*

Specific rooms: *none*

Prerequisites: *no prerequisites (usual post-preparatory class standard)*

Lecturer(s): V. Le Courtois, J.M. Foucaut, P. Dupont, M. Stanislas, S. Paul, D. Balloy

Objectives

Knowledge:

- Know how to establish equations of conservation of momentum, mass and energy.
- Know the concepts of velocity profiles, diffusion, conduction, convection and radiation.
- Know the fundamental equations for understanding these phenomena: Fick's law, Fourier's law, Newton's law, etc.
- Know how to draw analogies between these different transport modes.

Skills:

- Solve equations of momentum, mass and energy conservation in simple example applications by using well-justified simplifying assumptions.
- Know how to use dimensional analysis.

Module Content Summary.

General introduction

- Establishing equations from main tenets: conservation of mass, dynamic equation and first law of thermodynamics applied to a moving fluid.
- Analogy between different transport modes.
- Principle of dimensional analysis and Buckingham Pi theorem.

Heat transfer

- Various modes of heat transfer: conduction, convection, radiation.
- Combined transfer mode: general equation governing heat exchange around a point, heat transfer through a wall.

Momentum transfer

- Momentum equation, case of an ideal fluid
 - Key assumptions, Bernoulli's principle (tutorial 1)
 - Demonstration of convection
 - Influence of compressibility
 - Application to de Laval nozzle (tutorial 1)
- Momentum equation, case of isovolume viscous fluids
 - Constitutive equation (Newton)
 - Demonstration of viscous diffusion
 - Application to plane channel flow (tutorial 2)
 - Simplification of NS equations using normalisation
 - Stokes flow (tutorial 3)
 - Boundary-layer flow
 - Introduction to turbulence, turbulent diffusion

Mass transfer

- Examples of natural phenomena related to mass transfer
- Transport by diffusion
 - Expressing mass transfer in equation form – generalised Fick's law
 - Equimolar counter-diffusion

- Diffusion of A into stationary B
- Theory of films
 - Assumptions and representation of a film
 - Approximation using a Fick-type law for convective-diffusive transport
 - Mass transfer coefficient

Thermodynamics and Matter

Department: *Physical Sciences*

Year: *G1*

Category: *Core curriculum*

Semester: *S6*

Duration: *32 h*

Organisation: *14h PBL (of which 6h unsupervised work), 10h lectures, 6h tutorials, 2h exam*

Assessment: *Final exam and PBL*

Specific rooms: *computer labs for PBL assessment*

Prerequisites: *thermodynamics (functions, 1st and 2nd laws), phase equilibrium of pure substances, some concepts of the structure of matter*

Lecturer(s): D. Balloy, P. Dupont, P. Fongarland, J.M. Foucaut, V. Le Courtois, S. Paul

Objectives

The objective of this module is to provide students with basic concepts in thermodynamics for analysing, dimensioning and modelling heat engines and thermodynamic separation operations. We will demonstrate how these thermodynamic concepts are linked to the microstructure of solid materials and coating growth. The relationship between the macroscopic properties of materials and their crystalline defects will be covered.

Knowledge:

- Concepts of phase equilibrium and ideality in thermodynamic terms (Raoult's law and Henry's law)
- Concepts of excess free enthalpy, chemical potential, fugacity. Relationship between these quantities, expressing phase equilibrium in equation form. Simple thermodynamic models of these equilibria.
- Concepts of thermodynamic cycle for single- or two-phase pure substances. Concept of efficiency and work, comparison with Carnot cycle.
- Knowledge of crystalline defects and the macroscopic properties of materials.

Skills:

- Read and interpret equilibrium diagrams.
- Calculate certain thermodynamic characteristics (bubble points and dew points).
- Propose and validate a phase equilibrium model for any binary system. Predict the behaviour of a binary or ternary system.
- Use diagrams of single- or multiphase pure substances (pv, Ts, hs, ph).
- Characterise the engine cycles of ideal gas heat engines (Joule cycle) and mixed-phase (liquid-vapour) heat engines (Hirn and Rankine cycles).
- Use equilibrium diagrams to predict microstructures in "vertical reading" (isocomposition) or "horizontal reading" (isothermal).

Module Content Summary.

There are three parts to this module:

- problem-based learning on liquid-vapour equilibrium calculations for binary or ternary systems
- a lecture on liquid/solid and solid/solid phase equilibria
- seminars on the thermodynamics of cycles.

Aero-Hydrodynamics

Department: *Physical Sciences*

Year: *G2*

Category: *Core curriculum*

Semester: *S7*

Duration: *32 h*

Organisation: *Lectures (11h), unsupervised work (5h), tutorials (12h), lab sessions (4h)*

Assessment: *Exam*

Specific rooms: *Fluid Mechanics lab*

Prerequisites: *Transport Phenomena*

Lecturer(s): J.M. Foucaut, P. Dupont, M. Stanislas

Objectives

- Know how to write up and solve equations in fluid mechanics.
- Know the concepts of velocity profiles, pressure loss, flow rate, viscosity.
- Know the main principles of similitude.
- Know how to calculate forces exerted by a fluid on a solid.
- Know how to carry out calculations for an industrial system.

Module Content Summary.

- General introduction
 - Position of Fluid Mechanics in the field of physics
 - Revision
- Dynamics of ideal fluids
 - Euler's (or momentum) equation,
 - Concept of a compressible fluid:
 - Plane shock waves,
 - Oblique shock waves.
- Dynamics of isovolume viscous fluids:
 - Navier-Stokes (NS) equations,
 - NS in cylindrical coordinates,
 - Exact solution of Navier-Stokes equations:
 - Couette viscosimeter,
 - Duct flow,
 - Plane parallel flow,
 - Friction-induced pressure loss,
 - Singular pressure loss,
 - Pumps and fans, machine applications,
 - Similitude,
 - Froude similitude
 - Strouhal similitude
 - Mach similitude

Materials Science

Department: *Physical Sciences*

Year: *G2*

Category: *Core curriculum*

Semester: *S7*

Duration: *32 h*

Organisation: *Series of lectures/tutorials and lab sessions*

Assessment: *Continuous assessment and tests*

Specific rooms: *Materials Science Laboratory*

Prerequisites: *Good grounding in concepts covered in "Thermodynamics and Matter" module*

Lecturer(s): D. Balloy, A.-L. Cristol, C. Davy

Objectives

Knowledge:

The Materials Science module will begin with an overview of the main categories of industrial materials in terms of technical data as well as areas of application and the associated economic considerations. It will initially focus on the macroscopic properties of solid materials, especially through the characterisation of mechanical properties of various materials such as polymers (PVC, nylon, rubber) and metals (iron, copper, aluminium) in various metallurgical states.

Differences in the behaviour of various metal alloys will be explored by studying the link between composition and microstructure, through the use of phase diagrams, thermal analysis and optical microscopy.

Next, the main methods of modifying a metallic material's properties (mechanical, thermal) will be covered. The basic concepts of heat treatments for controlling metastable components and their gradual evolution will enable engineering students to gain insight into the different ways of modifying the macroscopic mechanical properties of industrial metal alloys. When presented with an application, they will be able to choose the best alloy/treatment combination and answer some basic questions such as: is it possible to use the same material for car and train suspension springs, a transmission shaft or a mill?

Skills:

Know how to carry out and/or use

- tests for characterising mechanical properties of materials (tensile, impact strength, hardness)
- equilibrium diagrams and thermal analysis
- optical microscopy
- basic heat treatments for metals

Module Content Summary.

- The main categories of industrial materials (technical and economic data and areas of application):
Traditional materials, advanced materials, new materials
- Macroscopic properties of solid materials
 - Mechanical properties and characterisation (elasticity, plasticity, failure)
- Microstructure – Transformation - Properties
 - Modification of properties via phase changes,
 - Kinds of transformations,
 - Nucleation, growth, impeding transformations
 - Metastable states
- Associated characterisation techniques

Quantum physics

Department: *Physical Sciences*

Year: *G1*

Category: *Discipline-based elective module*

Semester: *S6*

Duration: *32 h*

Organisation: *Series of 2h or 4h lectures, totalling 24 h.*

Assessment: *written exam*

Specific rooms: *no known constraints, individual work may be carried out in any computer lab equipped with the appropriate software*

Prerequisites: *no prerequisites (usual post-preparatory class standard)*

Lecturer(s): V. Preobrajenski

Objectives

Quantum physics is the science of motion in the microworld and the science of the structure of matter. It is the foundation of atomic physics and spectroscopy, solid-state physics (especially the physics of semi-conductors and superconductors), magnetism, electromagnetic wave-matter interaction, physical chemistry, nuclear physics and astrophysics. Quantum mechanics is also one of the foundations of solid-state electronics, nanophysics, laser engineering, magnetic resonance and tomography, scanning tunnelling microscopy, quantum interferometric devices, as well as other areas of modern engineering. It also constitutes a methodological basis for research in physics, especially measure theory.

This module is intended for students who are highly motivated and wish to further their knowledge of electronics, optics, acoustics, radiation physics and modern engineering in general.

Module Content Summary.

- Introduction: Contradictions in classical physics: UV catastrophe, accuracy of photoelectric effect, instability of the classical atom
Quantum hypothesis: Photon energy and impulse, Planck's radiation law, Einstein's law of the photoelectric effect, Compton effect, Bohr atomic model, de Broglie's assumption, principle of superposition, statistical interpretation of the wave function, uncertainty principle
- Schrödinger equation: Correspondence principle, WKB quasi-classical approximation, probability current density, particle in potential well, energy quantification, potential barrier, tunnel effect, non-stationary Josephson effect, harmonic oscillator, electron in a homogeneous electric field
- Postulates and formalism of quantum mechanics: operators associated with physical quantities, average value, eigenfunctions and eigenvalues, commutators, Heisenberg's uncertainty principle, Ehrenfest's theorems, quantification of angular momentum
- Hydrogen atom: Quantification of energy, classification of quantum states, orbital angular momentum
- Electron spin: Pauli matrices, identical particles, Pauli principle, helium atom, exchange interaction, magnetic moment, Paschen-Back and Zeeman effects, spin-orbit interaction. Mendeleev's table.
- Perturbation theory: Stationary perturbations, Stark effect, electron in a periodic field. Quantum transitions, magnetic resonance, stimulated emission, MASER effect
- Secondary quantification: Secondary quantification of the harmonic oscillator, creation and annihilation operators, elastic chain, phonons, spin chain, Holstein-Primakof operators, magnons, quantification of electromagnetic field, phonon absorption and emission.
- Quantum statics: Density matrix, Gibbs distribution, Fermi-Dirac distribution, degenerate electron gas, density of state, Fermi energy, Bose-Einstein distribution, Bose condensation.

Processing Techniques of Today and Tomorrow

Department: *Physical Sciences*

Year: *G1*

Category: *Discipline-based elective module*

Semester: *S6*

Duration: *32h*

Organisation: *14h lectures + 18h project work (12h unsupervised and 6h with lecturer)*

Assessment: *attendance, mini-project in groups of two or three (report and oral presentation)*

Specific rooms: *none*

Prerequisites: *none*

Lecturer(s): S. Paul

Objectives

By the end of this module, students:

- will have an overall vision of how the chemical industry is organised and the main challenges that it faces,
- will have identified the raw materials and energy sources of this industrial sector and formed an idea of their availability,
- will know how to list the key sectors that produce petrochemicals and carbochemicals,
- will be able to explain how to integrate sustainable development within this industrial sector.

Module Content Summary.

- Chemistry and Processing Techniques
 - General organisation of the sector
 - Some economic data
 - What is a chemical process and why should we make changes to it?
- Sources of energy and raw materials
 - Non-renewable
 - Renewable
- Examples of raw materials processing (current techniques)
 - In the petrochemical sector (refineries, etc.)
 - In the carbochemical sector
- Integrating sustainable development in the chemical industry (techniques of tomorrow)
 - Green chemistry (biorefineries, etc.)
 - Process intensification

Mini-project:

Group project on a subject proposed by the lecturer or chosen by the students themselves

- Starting point: an everyday object
- Search for the main chemical compound of the object
- Study of its production sector(s) from technical, economic and environmental viewpoints
- Comparison of existing processing techniques and the various alternatives that are still in the R&D stage

Experimental and Numerical Fluid Mechanics

Department: *Physical Sciences*

Year: *G1*

Category: *Discipline-based elective module*

Semester: *S6*

Duration: *32 h*

Organisation : *Three 4h lectures on methods and two 8h lab sessions per half class (4h unsupervised numerical lab work), the last session will involve 2h of numerical lab work, a visit to the LML wind tunnel (1h) and a presentation by an industry guest speaker (1h).*

Assessment: *Lab work*

Specific rooms: *Lab + 2 fully equipped computer labs*

Prerequisites: *Transport Phenomena*

Lecturer(s): J.M. Foucaut, P. Dupont, M. Stanislas

Objectives

Know the various experimental methods in fluid mechanics

- Familiarise students with experiments.
- Learn how to go about modelling an industrial problem.
- Compare experimental techniques with computational approaches.

Module Content Summary.

- Experimental techniques in Fluid Mechanics
 - Wind tunnels
 - Force and pressure measurement
 - Anemometry based on heat transfer
 - Optical methods:
 - Visualisation
 - Laser Doppler Anemometry
 - Particle Image Velocimetry
- Numerical methods
 - Solving systems with differential equations or partial derivatives
 - Derivative of a function
 - Numerical resolution of ordinary differential equations
 - Finite difference method
 - Finite volume method
 - Application to fluids, modelling turbulence
 - Industrial computation code
- Comparison and complementarity
- Visit to LML wind tunnel
- Talk on real problems by an industry expert (research engineer at ONERA)

Distillation

Department: *Physical Sciences*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7*

Duration: *32h*

Organisation: *21h seminars + 8h lab work*

Assessment: *Attendance, lab work and exam*

Specific rooms: *Lab sessions in C012*

Prerequisites: *none*

Lecturer(s): *V. Le Courtois, S. Paul*

Objectives

Knowledge:

By the end of this module, students will be able to:

- identify mass, heat and momentum transfer phenomena related to distillation processes,
- express mass and heat transfer processes in equation form,
- explain the concepts of theoretical plate and efficiency (physical plate),
- apply the equations governing phase equilibria during distillation (deviations with respect to ideality, azeotropy, heteroazeotropy),
- explain the operating principle of a distillation column,
- describe the main technologies used.

Skills:

Implement the McCabe-Thiele and/or Ponchon-Savarit methods to make a rough design of a distillation column (i.e. determine the number of theoretical plates required to bring about a given exchange under fixed operating conditions) or optimise the operating conditions of an existing column for a given separation process.

Module Content Summary.

- Revision of the laws of thermodynamic equilibrium
- Establishing mass and energy balances
- Study of the transfer processes in distillation (methods and techniques)
- Theoretical plate: graphical representation; combining theoretical plates
- Rectification: graphical resolution methods (McCabe-Thiele and Ponchon-Savarit)
- Design aspects (economic and hydrodynamic)
- Continuous and discontinuous processes
- Kinetics of mass transfer
- Concept of efficiency

Fluid Energetics

Department: *Physical Sciences*

Year: G2

Category: *Discipline-based elective module*

Semester: S7

Duration: 32 h

Organisation: *6 x 4 h seminars + 8h unsupervised work*

Assessment: *Study of an energy system*

Specific rooms: *none*

Prerequisites: *Thermodynamics and Matter*

Lecturer(s): J.M. Foucaut, P. Dupont

Objectives

Knowledge:

Master the principles of thermodynamics:

- Know how to analyse and characterise an engine or generator cycle
- Know the thermodynamic characteristics of fluids
- Study the different types of gas and steam engines

Skills:

Know how to carry out calculations relating to an industrial system

Module Content Summary.

- General concepts and fundamental principles
- Thermodynamic study of gas engines
 - Thermodynamic properties of gases,
 - Gas engine cycles
 - Joule cycle and derivatives. Gas turbines
- Combustion
 - Modelling combustion, principle of combustion
 - Study of combustion in heat engines
 - Pollution sources and reduction
- Thermodynamic study of steam engines
 - Thermodynamic characteristics of multiphase fluids
 - Cycles of steam-powered systems
 - Vapour compressors: refrigerators, heat pumps, geothermal energy
- Wind energy
 - Principle of turbine blades
 - Different types of wind turbines and their energy characteristics
- Hydroelectric power
 - Dams and rivers
 - Pumps and turbines
 - Marine energy
- Solar power
 - The Sun
 - Availability of the source
 - Flat-plate collectors
- Exergy
 - Energy assessment with reference to ambient environment
 - Exergy balance
 - Study of exergy losses
 - Examples of application to energy systems

Fluid Transfer Devices

Department: *Physical Sciences*

Year: G2

Category: *Discipline-based elective module*

Semester: S8

Duration: 32 h

Organisation: *lectures, tutorials and lab sessions*

Assessment: *assignments as part of unsupervised work and lab report*

Specific rooms: *lab facilities of the Ecole des ARTS ET METIER PariTech Centre de Lille and fluid mechanics lab at the Ecole Centrale de Lille.*

Prerequisites: *Aero-hydrodynamics*

Lecturer(s): P. Dupont, A. Dazin.

Objectives

- Nowadays, there is a demand for increasingly compact, high-performance machines (greater efficiency, more extensive operating ranges) that comply with the latest standards. Achieving this requires an understanding of the internal flow of machines as well as machine/circuit interaction.
- Apply concepts learnt in thermodynamics, fluid mechanics and mechanics in general.
- Demonstrate the multidisciplinary nature of the analysis of a system: machine start-up, operating stability, circuit response time.
- Introduce students to research facilities that are unique to Europe: fast pump start-up loop, cavitation loop and test benches.
- Create an exercise database and report on attainable projects.

Module Content Summary.

- General concepts and principles of compressible-fluid and incompressible-fluid machines (overview of module and assignments posted on the intranet)
- Lab work on machine bed and presentation of test facilities (8 hours – maximum 12 students):
 - - Lab session: pump-turbine
 - Lab session: pumps in series and in parallel
 - Lab session: cavitation loop
 - Debriefing – questions (1h)
- Visit to a university research laboratory, participation by industry expert
- Validation in the form of assignments and oral presentations.

Experimental Methods in Materials Science

Department: *Physical Sciences*

Year: G2

Category: *Discipline-based elective module*

Semester: S7

Duration: 32 h

Organisation: *Lectures, problem-based learning*

Assessment: *Diligence/attendance, oral presentation and report*

Specific rooms: *Materials Science Laboratory, SEM*

Prerequisites: *Core curriculum – Materials Science*

Lecturer(s): D. Balloy, A.-L. Cristol,

Objectives

Knowledge:

The Experimental Methods in Materials Science module aims to provide students with both theoretical knowledge and experimental skills in the main techniques used to observe and characterise materials.

Skills:

Practical application of theoretical knowledge will be centred around mini research projects on industrial problems. After analysing the problem, students will work in groups of three or four to define and implement a scientific procedure.

Experimental work will be a key feature in this module; all the facilities in the Materials Science lab will be available for use. These include the processing (induction melting furnace, galvanising furnace, sintering press, heat treating furnaces, etc.) and analysis and characterisation (optical microscopes, scanning electron microscopes, glow discharge spectrometer, techniques for carrying out physical measurements and characterising mechanical behaviour, etc.) facilities.

Module Content Summary.

- Analysis methods,
- Scanning Electron Microscopy and Microanalysis,
- X-ray diffraction,
- Case study in groups of four:
 - Problem analysis,
 - Determination of scientific approach,
 - Implementation,
 - Submission of summary report and presentation/discussion of other groups' results.

Material Selection

Department: *Physical Sciences*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7*

Duration: *32 h*

Organisation: *Problem-based learning*

Individual work: *8h*

Assessment: *Oral presentation and written report*

Specific rooms: *Materials Science Laboratory, SEM*

Prerequisites: *Core curriculum – Materials Science*

Lecturer(s): *D. Balloy, A.-L. Cristol,*

Objectives

Knowledge:

How to choose a material in accordance with constraints set out in specifications.

Skills:

First, a needs assessment has to be carried out by analysing the requirements related to the choice of material based on design constraints (mechanical, thermal, electrical, etc.) for the part involved. A performance index can then be defined in order to optimise this choice with regard to a given objective, which is often cost related. This index enables the use of rational methods (performance indices) and material selection software (Fuzzymat, CES).

This approach will be put into practice in case studies on small mass-produced items, such as spark plugs, hard drives or electronic lighters. A large portion of the module will be devoted to the observation and characterisation of materials used in older and recent versions, in order to discover the changes in terms of material choice as well as forming and assembly techniques. All the characterisation facilities of the Materials Science laboratory will be available for use. Each group will get to examine its object in a Scanning Electron Microscope, an essential observation and analysis tool in the field of materials.

Later on in the module, there will be discussions on the directions taken or to be taken based on availability, fluctuations in the prices of raw materials, regulations and the impact on the environment.

Module Content Summary.

- Needs assessment: requirements linked to material choice
 - Functional requirements, technological requirements, economic requirements, social requirements.
- Application of the performance index method
 - Material selection software,
 - Application of performance indices,
 - Example case studies on paper.
- Case study on objects, in groups of two or three students
 - Introduction,
 - Functional study, defining specifications,
 - Observation and analysis of technological choices for a mass-produced item (use of characterisation techniques such as Scanning Electron Microscopy),
 - Using software,
 - Proposing new solutions,
 - Considering alternative solutions (e.g. recycling),
 - Submission of summary report, presentation and discussion of results with other students,
 - Debriefing.

Failure of Materials 1: Corrosion and Remedies

Department: *Physical Sciences*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *Problem-based learning*

Assessment: *Assessment of oral presentation and report*

Specific rooms: *Materials Science Laboratory, SEM*

Prerequisites: *Materials Science*

Lecturer(s): *D. Balloy, A-L Cristol, J-Y Dauphin, J-C Tissier*

Objectives

Loosely speaking, corrosion may be described as a change in a material when it undergoes a chemical reaction with its environment. The most well-known forms of corrosion are rust, which forms on ferrous metals, and verdigris, which appears on copper and its alloys. The deterioration of materials by corrosion is a major industrial problem. It is estimated that five tonnes of steel are converted into iron oxide every second.

This module aims to provide students with theoretical knowledge on the basic principles of corrosion. Methods for quantifying corrosion will be taught in the form of experiments and the various means of inhibiting corrosion will be investigated. Students will get to apply acquired skills and knowledge in a case study on an industrial corrosion problem.

Module Content Summary.

- Basic principles of corrosion phenomena
- Methods for quantifying corrosion
 - Measuring potentials,
 - Measuring corrosion rates,
 - Galvanic coupling,
 - Differential aeration.
- Methods for protecting metals against corrosion
 - Anodic protection,
 - Cathodic protection,
 - Passivable materials,
 - Organic coatings,
 - Active protection.
- Case study
 - Introduction,
 - Problem analysis and diagnosis,
 - Demonstration through measurements,
 - Proposal of solutions with associated arguments,
 - Submission of summary report, presentation and discussion of results with other students,
 - Debriefing.

Wave Imaging Systems

Department: *Physical Sciences*

Year: *G1*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *Series of six 4h seminars, alternating between lectures, tutorials, demonstrations, videos and numerical simulations on PC*

Assessment: *written exam*

Specific rooms: *no known constraints, individual work may be carried out in any computer lab equipped with the appropriate software*

Prerequisites: *no prerequisites (usual post-preparatory class standard)*

Lecturer(s): Ph. Pernod

Objectives

Knowledge:

Basic and modern methods in wave imaging and remote sensing, with unified vision of Acoustic Waves and Electromagnetic Waves of all frequencies (transmission imaging, tomography techniques, ultrasound techniques, 3D reconstruction, non-linear imaging, etc.). Knowledge of the characteristic parameters of waves for selecting concepts, dimensioning systems and evaluating the performance of systems in Remote Sensing, Imaging and Telecommunications. Knowledge of the operating principles of main applications in these three areas (radars, sonars, ultrasound techniques, satellite imaging, X-ray imaging systems and scanners, MRI, etc.). Knowledge of how the systems in such devices are organised (block diagrams). Introduction to the latest methods in imaging (3D, 3.5D and 4D imaging, portable ultrasonography, time reversal and phase conjugation, elastography, non-linear imaging, etc.). Introduction to active materials and the technological aspects of imaging devices. Introduction to powerful ultrasonography, actuators and sensors based on wave phenomena, wave microsystems, etc.

Skills:

Know how to exploit wave potential to carry out imaging, operating or sensing functions. Know how to choose and dimension the main sources and transmission-reception aerials used in Telecommunications, Remote Sensing and Imaging applications (satellites, radars, sonars, non-destructive testing, ultrasound, etc.). Know how to assess their characteristics and performance (radiation pattern, focusing power, axial and lateral resolutions, etc.). Know how to make a synoptic description of basic devices. Know how to identify key technologies for building a system. Know how to come up with alternative design solutions by transposing those studied in the module.

There will be many examples and videos of real systems, as well as demonstrations and numerical simulations.

Module Content Summary.

- Introduction: Aim of module = Overall approach to the use of Acoustic and Electromagnetic Waves in wave imaging. Overview of electromagnetic, acoustic and ultrasound applications.
- Variables in acoustics, assumptions in acoustics, demonstration of acoustic propagation equations. Plane wave and spherical wave solutions. Analogies with Maxwell's equations and acoustics/electromagnetism analogies. General case.
- Radiation of elementary wave sources (pulsating sphere, monopole) – Creating directivity of wave sources by combining single sources – Aerial theory: Array aerials and weighted linear aerials (phased aerials, cosine-weighted aerials) – Introduction to beamforming in sensing and imaging systems (scanning electron, electronic focusing, aperture synthesis, etc.) – Illustrations: seismic imaging, sonars, synthetic aerials for satellite imaging, etc.
- Radiation of diffuse sources. Analogies with diffraction – Kirchhoff's law, Rayleigh's law, Sommerfeld's law and general case – Special case of rectangular and circular sources (far fields and radiation patterns, study of near-field behaviour) – Applications to sources of ultrasound non-destructive testing, radar and satellite aerials, etc.
- Arrays of diffuse sources – Electronic scanning or focusing ultrasound probes – Image forming methods – Introduction to wave imaging systems design.

- Ultrasound imaging systems for medical applications or industrial non-destructive testing: A-scan, B-scan, C-scan ultrasound, acoustic microscopy, Doppler, Time Motion, Holography. New techniques: Time reversal and phase conjugation, non-linear imaging techniques, harmonic imaging, elastography, vibro-acoustography, etc.
- Introduction to active materials (piezoelectric, ferroelectric, magnetostrictive, etc.) and the technological aspects of imaging devices (e.g. production of ultrasound imaging probes).

Transposition to the field of electromagnetics. X-ray imaging techniques: The technological difficulties that limit the level of sophistication of concepts relating to optical or ultrasound techniques / Why? Radiographic techniques, Computed tomography (medical scanner). General cases. Magnetic Resonance Imaging MRI.

Aerodynamics for Transport Systems

Department: *Physical Sciences*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *6 x 4 h seminars + 8h unsupervised work.*

Assessment: *Case studies*

Specific rooms: *none*

Prerequisites: *Aero-Hydrodynamics*

Lecturer(s): J.M. Foucaut, M. Stanislas

Objectives

- Study the influence of viscosity and compressibility on the aerodynamics of a system.
- Know how to calculate the forces exerted by a moving fluid on a solid.
- Know the main aerodynamic problems encountered in the various land and air transport industries.

Module Content Summary.

- Equations in aerodynamics
 - Navier-Stokes equations and main effects of viscosity
 - Reynolds equation and turbulence
 - Boundary layers and wakes
 - Effect of compressibility: transonic, supersonic and hypersonic flows.
- Aerodynamic characterisation
 - Aerodynamic loads
 - Assessment of drag and power consumption
 - Aerodynamics of foils
 - Wind tunnel aerodynamics (plane, car, etc.)
 - Numerical aerodynamics
- Advanced aerodynamics
 - Aerodynamic noise
 - Flow control
- Case study (unsupervised work)
- Seminar by guest speaker from aerodynamics industry

Kinetics and Reactors

Department: *Physical Sciences*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7*

Duration: *32 h*

Organisation: *18 h seminars (lectures + tutorials), 6 h numerical lab sessions, 8 h project*

Assessment: *Oral presentation on project, written exam*

Specific rooms: *computer lab for numerical lab sessions*

Prerequisites: *Transport Phenomena (S5)*

Lecturer(s): P. Fongarland, S. Paul

Objectives

- Know the different types of reactors and implementations in industry
- Know how to establish mass and energy balance in a reactor
- Dimension and adapt a reactor to a process
- Know how to select different forms of kinetic laws according to the kind of reaction (homogeneous, heterogeneous, biological, radical)
- Know how to express simple kinetics in equation form
- Be able to incorporate a kinetic law into a mass and energy balance for a reactor and calculate its efficiency

Module Content Summary.

- Reactors and reactions in industrial processes (2h)
 - Chemical and petrol industry
 - Food industry
 - Fine chemical industry
 - Environment
 - Energy
- Homogeneous reactors (12h)
 - Assumptions and simplifications
 - Mass and energy balance
 - Model of completely-mixed-flow reactor
 - Model of plug-flow reactor
 - Simulation of ideal reactors
- Basic kinetics (8 h)
 - Chemical thermodynamics (calculating reaction equilibria)
 - Basic reactions
 - Mechanisms and equation writing
 - Approximation of the quasi-stationary state
 - Example case studies
 - Kinetic modelling (2h numerical lab work)
- Project: dimensioning a reactor for a given process (8h project work)

Production of Industrial Materials

Department: *Physical Sciences*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation:

Assessment: *Assessment of oral presentation and report*

Specific rooms: *none*

Prerequisites: *Materials Science*

Lecturer(s): D. Balloy, A-L Cristol, J-Y Dauphin, J-C Tissier

Objectives

Man has many materials at his disposal for producing everyday items. Although ceramics belong to the oldest category of materials, their continuous development has given rise to a new generation of so-called "technical", very high-performance ceramics, which have remarkable properties such as resistance to extremely high temperatures. Just as the coal and steel eras contributed greatly to the development of metallic materials, the petroleum era can be credited with the boom in the production of polymers. Without wanting to over-caricature the situation, one may say that during the twentieth century, the major industrial countries produced vast amounts of a variety of materials without truly bothering about resource sustainability or the impact on the environment.

Today, we live in the post-petroleum and global warming era. Resource management, renewable energies, sustainable development, carbon footprint, valorisation, recycling, costs and markets are just a few keywords that govern all future strategies for the sustainable production of materials. Given these additional constraints, are certain categories of materials doomed to extinction? If so, what are the possible substitutes and alternative perspectives?

The Production of Industrial Materials module is designed to provide an insight into the reality of the production of the main industrial materials, in the most objective manner possible. This will be achieved by examining their strengths and weaknesses with regard to current and future constraints.

Module Content Summary.

- The major categories of materials and their properties (revision)
Metals - polymers - ceramics - composites – fabrics – wood, etc.

For each category and subcategory:

- Schematic description of upstream production sectors and techniques (e.g. from iron ore to steel, via the conversion of cast iron)
- Resources
 - Deposits and reserves, geopolitical aspects, economic aspects
 - Actors (global/European/national) in different sectors
- Detailed description of various production sectors and techniques
 - Processing principles for different parent materials.
 - Material resources used
 - Implementation techniques and associated resources – Products obtained
 - Energy aspects – production costs - carbon footprint – environmental aspects
- Possibilities for recycling and valorisation
 - Collection – circuits – organisation - actors
 - Recycling and valorisation processes and techniques
 - Products obtained - properties
 - Possibilities and areas for reuse
 - Energy aspects – production costs – environmental aspects
- Group work (two or three students per group): all-round analysis of the production of a particular material. Written work and oral presentation.

Department of Mechanisms, Structures and
Construction.

Curricular Harmonisation in Mechanics

Department: *Mechanisms, Structures and Construction*

Category: *Curricular harmonisation*

Semester: *S1*

Duration: *8h reading engineering drawings and 8h curricular harmonisation in mechanics*

Organisation: *Four 2h sessions on reading engineering drawings and four 2h sessions in Mechanics*

Assessment: *none*

No. of students: *maximum 18*

Specific rooms: *B24/B28 and B14/B15*

Prerequisites: *no prerequisites*

Lecturers: Pierre Hottebart, Bouaziz Tolba

Objectives.

Reading engineering drawings:

In the course of their studies or working life, engineering students may have to study the operating principle of a mechanism based on its assembly drawing. The aim of the Curricular Harmonisation in Mechanics module is to provide students with the relevant knowledge of rules and techniques for understanding engineering drawings.

Mechanics:

The objective of Curricular Harmonisation in Mechanics is to provide students with sufficient skills and knowledge in statics, kinematics and links to take the module in Mechanics of Mechanisms and Structural Mechanics. Theoretical aspects will be accompanied by many exercises and applications that will allow students to put into practice various concepts in solid mechanics.

Module Content Summary.

Reading engineering drawings:

- Identifying needs
Study of a nibbler, lesson on mechanical construction (orthographic projection) and exercises (drawing different part views).
- Comparison between assembly drawings and real mechanisms
Lesson on mechanical construction (cuts and sections) and exercises (master drawing).
- Using an assembly drawing
Lesson on mechanical construction (characterising fixed links between mechanical parts) and exercises (reading engineering drawings, kinematic diagrams, master drawings).
- Validation of acquired skills and knowledge
Read an assembly drawing and use the mechanism portrayed.

Solid Mechanics:

- Analysis of mechanisms
Introduction to concepts of mechanisms and links. Analysis of standardised links during lab session. Concept of bond graphs and kinematic diagrams, application to real mechanisms.
- Statics of solid systems
Lesson on statics (calculation figures, modelling mechanical actions, moment transfer, wrench, equilibrium of solid systems). Exercises on statics of simple systems.
- Kinematics of solid systems
Lesson on kinematics (rotational speed of a solid, velocity field, twist, velocity components). Exercises on kinematics of simple systems.

Structural Mechanics

Department: *Mechanisms, Structures and Construction*

Year: *G1*

Category: *Core curriculum*

Semester: *S5*

Duration: *32 h*

Organisation:

Assessment:

Specific rooms:

Prerequisites:

Lecturer(s): Agostini Franck, Brieu Mathias, Skoczylas Frederic, Quaegebeur Philippe, Desplanques Yannick, Niclaeys Christophe, Lafhaj Zoubeir, Davy Catherine, Leblanc Alain.

Objectives.

This module will be held in the 1st semester after the "Mechanics of Mechanisms" (mechanics of non-deformable solids) course.

At the end of this 32h module, first-year students will have acquired knowledge of the basic theory and main computing tools in mechanics of deformable solids and structures.

They should be able to:

- Define a rod or beam (N1),
- Define (N1) and use (N3) Saint Venant's and Navier's assumptions,
- Define (N1) and use (N3) the concept of local equilibrium for calculating (N3) generalised stresses,
- Describe (N2) and use (N3) constitutive laws (linear elasticity),
- Define (N1), establish and use (N3) stress and strain tensors. Calculate (N3) principal stresses and strains,
- Describe (N2) and use (N3) criteria (Tresca, von Mises, Mohr Coulomb),
- Describe (N2) and dimension (N3) a simple predefined structure,
- Describe (N2) and analyse (N4) a real system.

Module Content Summary.

Sessions:

- 1) & 2) 4h tutorial: Learn concepts of stress and strain through case studies. Approach to deformation in simple tension/compression: virtual cutting, concept of stress, dimensioning. Approach to slip, shear and torsion by dimensioning simple elements (rivets, weld seams, transmission shafts, etc.).
- 3) 2h tutorial: Definition of local coordinate system, definition and expression of generalised stresses in 3D. Simplification to the case of beams: generalised stresses, N , V M .
- 4) 2h tutorial: plotting diagrams and dimensioning with respect to normal forces, shear forces and bending moments.
- 5) 3h unsupervised work: plotting diagrams and dimensioning.
- 6) 2h tutorial: Concept of stress tensor and criteria: application to simple cases.
- 7) 2h tutorial: Concept of strain tensor, Navier-Bernoulli assumption.
- 8) 2h tutorial: Approach to beam deflection by solving $M=E.I.y''$
- 9) 2h tutorial: Using energy theorems and the principle of virtual work to determine displacements: application to the dimensioning of structures that experience displacement.
- 10) 2h tutorial: Learn about static indeterminacy and displacement methods for solving statically indeterminate structures.
- 11) 4h unsupervised work: Case study: dimensioning statically determinate and statically indeterminate structures.
- 12) 2h tutorial: Return to stresses and strains: constitutive laws.
- 13) 1h unsupervised work: Tensor calculations: assimilation of concepts covered in lectures: Einstein summation convention, Kronecker index.
- 14) 2h tutorial: material identification: application to the case of an orthotropic material.
- 15) 2h tutorial: Case study.

Mechanics of Mechanisms

Department: *Mechanisms, Structures and Construction*

Year: *G1*

Category: *Core curriculum*

Semester: *S5*

Duration: *32h*

Organisation:

Assessment:

Specific rooms:

Prerequisites: Basic knowledge of screw theory, wrench and twist
Kinematic diagrams, basic links
Reading engineering drawings

Session schedule over 12 weeks (w1 to w12):

w1: One 4h session [2h seminar, 1h supervised PBL, 1h unsupervised PBL]; PBL and unsupervised work per half class (two adjacent rooms)

w2: One 4h session = [2h supervised PBL, 2h unsupervised PBL]: per half class (two adjacent rooms)

w3: One 2h session = [1h unsupervised PBL, 1h supervised PBL]: per half class (two adjacent rooms)

w4-7: Five 2h sessions in seminar form,

w8 & 9: One 4h lab session per half class (**rooms B24-B28**)

w10 & 11: Three 2h sessions: 2h seminar + 2h unsupervised work + 2h seminar

w12: 2h test

The introductory PBL of the module comprises **3 teaching sessions** over the course of **3 weeks** (1 session per week) in order to allow time for self-study for students with little prior knowledge of mechanics:

- Session 1 (4h): 1st seminar on kinematics (2h, "revision" + creating need for PBL), 1 h PBL simulation/role play (supervised per half class) followed by 1h unsupervised work;
- Session 2 (4h): 2h intermediate PBL supervised per half class, followed by 2h unsupervised work

Leave time between 2 sessions for self-study.

- Session 3 (2h): 1 h unsupervised work + 1 h PBL per half class

Pace: Maximum of 2 seminar sessions per week and per half class to allow proper assimilation of knowledge and time for self-study for students with very little prior knowledge of mechanics.

Lecturers: Emmanuel Berté, Julien Berthe, Xavier Boidin, Yannick Desplanques, Ahmed El Bartali, Pauline Lecomte, Philippe Quagebeur.

Objectives.

Knowledge:

Parameterisation, form closure, mobility and static indeterminacy of a mechanism. Technology and kinematics of links. Principle of Virtual Work and applications. Lagrangian method.

Skills:

Know how to parameterise a system. Determine an equivalent link. Analyse a kinematic diagram. Identify the objectives of a problem in dynamics. Determine the forces transmitted in a mechanism and/or a structure. Determine movements.

Module Content Summary.

- Parameterising a mechanism

Kinematics

Problem-based learning

Parameterisation - chain closure - simple closed continuous chain

Concepts of mobility, static indeterminacy, general static/kinematic law

Compound linkages, constructing simple linkages, technological examples

- Dynamic equilibrium

 - Definition of force, work

 - Principle of Virtual Work - Full formulation of equilibrium – Reciprocal actions

 - Application to non-deformable solids: General Theorems, Kinetic Energy Theorem

 - Calculating twist and dynamic screws, kinetic energy, inertia tensor

 - Lagrange applied to a solid, concept of partial velocity, energy coefficients

 - Lagrangian kinematic equation, energy coefficients for external mechanical actions

 - Lagrange applied to a mechanical system

 - Work by internal forces, linkage forces, energy coefficients of internal mechanical actions.

 - Determining equation of motion

- Methodology

 - Parameter and model choices - Incompatible parameterisation - Technological examples

 - Application to power transmission system

 - Dimensioning actuators, links, equations of motion

Systems Design

Department: *Mechanisms, Structures and Construction*

Year: *G1*

Category: *Core curriculum*

Semester: *S6*

Duration: *32 h*

Organisation: *Lectures, tutorials (24h supervised, 8h unsupervised)*

Individual work: 8 h

Assessment:

Specific rooms: *B28+B30 – B24+B05*

Prerequisites: *Curricular Harmonisation in Mechanics (Reading Engineering Drawings), Mechanics of Mechanisms, Dimensioning of Systems*

Lecturer(s): B. Tolba, P. Hottebart, L. Patrouix, D. Le Picart, Ph. Quagebeur.

Objectives.

- Given a specifications sheet, be able to choose the appropriate design and computation tools, integrate standard components and validate calculations.
- Describe how computer-aided analysis tools can influence product lifespan (computer-aided tools, PLM, etc.).
- Make appropriate use of CAD (CATIA) tools in the design process.
- Analyse the impact of production processes (machining, casting and forming) on parts design.
- Derive geometric and dimension specifications for a part from functional analysis (Fast, GPS, etc.).
- Generate an assembly drawing and a master drawing that include dimensioning to accommodate main functions.

Dimensioning of Systems

Department: *Mechanisms, Structures and Construction*

Year: *G1*

Category: *Core curriculum*

Semester: *S6*

Duration: *32 hours (of which 8h unsupervised)*

Organisation: *PBL (12h), Lectures (6h), Tutorials (8h), Lab sessions (4h), Exam (2h)*

Assessment: *continuous assessment (PBL) and final exam*

Specific rooms: *B24, B28, B05, B30*

Prerequisites:

- Basic knowledge of materials (density, Young's modulus, Poisson's ratio, etc.),
- Basic links between solids,
- Basic knowledge of screw theory, stresses and strains,
- Static equilibrium of solids (fundamental principle of statics),
- Dynamics of solids (fundamental principle of dynamics).

Lecturer(s): *A. El Bartali, X. Boidin, P. Hottebart, P. Lecomte, D. Le Picart A. Leblanc, B. Tolba.*

Objectives.

By the end of this 32h module, 1st year students will have understood the challenges involved in dimensioning and the role that engineers play in the choice of a design methodology.

They should be able to:

- describe and interpret dimensioning criteria for a mechanical system or structure (level 2: Comprehension),
- choose criteria that meet a given set of specifications (level 4: Analysis),
- use dimensioning techniques that meet static, kinematic and dynamic criteria in the case of mechanical systems and structures comprising about ten components (level 3: Application).
- use a simple computer tool (RdM Le Mans) for pre-project dimensioning (level 3: Application).

Knowledge:

- concept of specifications and dimensioning criteria
- choose essential criteria according to specifications
- choose a methodology that is suited to the dimensioning of a particular mechanical part

Skills:

- Use the RdM Le Mans tool
- Choose dimensions of contacting surfaces to create direct links
- Design and dimension links using rolling elements

Module Content Summary.

After an introduction to the role of the design engineer in construction and the importance of dimensioning criteria, students will be presented with a case study, a part of which will involve self-study.

Based on a real application and a set of specifications, they will be asked to determine the most important dimensioning criteria (strength, speed, cost, mass, ergonomics) and carry out a quantitative assessment of some of them.

Feedback will be given, with particular emphasis on fundamental criteria (static, kinematic and dynamic criteria). Based on a technological function, students will learn how to implement a methodology that meets specifications (calculation of contact pressure, dimensioning links, structural design analysis) in order to dimension the various parts of a mechanism.

Design and Manufacture

Department: *Mechanisms, Structures and Construction*

Year: *G1*

Category: *Core curriculum*

Semester: *S6*

Duration: *32h*

Organisation: *1h tutorial – 3h PBL – 1 h PBL – Five 4h lab/tutorial sessions – 4h PBL – 1 h PBL -2 h exam*

Assessment: *Continuous assessment + exam*

Specific rooms: *PBL in room B05, B24, B28 or B30 – Other sessions: production workshop + room B23 + B14 or B15*

Prerequisites: *reading technical drawings*

Lecturer(s): *X. Boidin - A.L. Cristol - P. Hottebart - D. Le Picart - C. Niclaeys - L. Patrouix - Ph. Quaegebeur*

Objectives.

At the end of this 32h module, first-year students will have acquired considerable technical knowledge of the main manufacturing methods and the difficulties related to the transition from model to real product (CAD model to manufactured product).

They will be able to:

- Determine criteria for justifying the choice of an appropriate process in terms of tolerance, cost, capability, production type, material, etc.;
- Identify sources of discrepancies between the model and the actual product;
- Relate these discrepancies to the various manufacturing processes;
- Calculate the cost of a particular operation;
- Demonstrate the importance or impact of a particular manufacturing method;
- Use existing standards;
- Analyse and use documents relating to production analysis.

NB: Acquiring hands-on skills is not one of the objectives of this module. An elective module is available for students who wish to further their knowledge and develop practical skills.

Module Content Summary.

- Problem-Based Learning 1: Introduction to problems related to manufacturing

Introduction to production of blanks and material removal processes, simulation of real production in which final assembly proves difficult, analysis of malfunctions, identification of discrepancies. Purpose of specifications and a standardised language, feedback on experience, recapitulation/summary.

- Introduction to machining processes

Analysis of various elements of the machining circuit, process implementation via two basic operations, checking of specifications, analysis of discrepancies - search for causes, summary: principle of generation, positioning, dispersions, machine and work-holder geometry.

- Manufacturing methods

Using documents on manufacturing methods, analysis of existing range, comparison between different scheduling schemes, choice of positioning.

- Study of the various elements in a numerical production line

Concept of machining cost and series, introduction to numerical line: from model to product, introduction to the functionalities of a CAM software, scheduling a range in CAM, optimising machining times, simulating and fine-tuning programmes, implementing a machining phase in a CNC machine.

- Fabrication and complementary role of machining

Introduction to cutting and bending processes, analysis of physical principles involved, thermal assembly, characterisation of fabricated product, re-machining to meet specifications, demonstration in machining centre - sequence of operations within a given stage, summary.

- Metrology and quality

Interpretation of standardised specifications (geometric and dimensional), image of surface produced through the choice of instrument and measurement method, characterisation of surface condition.

- Problem-Based Learning 2: Cost analysis

Based on a part produced in two or three phases, determine the overall production cost, compare costs between different series, influence of key parameters, return on investment, feedback on experience, recapitulation/summary. Assessment of knowledge in the form of an MCQ test.

Advanced Structural Design Analysis

Department: *Mechanisms, Structures and Construction*

Year: *G1*

Category: *Discipline-based elective module*

Semester: *S6*

Duration: *32h*

Organisation:

Assessment:

Specific rooms: *2 sessions with the RDM Le Mans software*

Prerequisites: *core curriculum modules: Physical Sciences, Structural Mechanics and Dimensioning*

Lecturer(s): F. Agostini, M. Brieu, F. Skoczylas.

Objectives.

This discipline-based elective module has been designed as a supplement to the core curriculum and aims to provide students with additional knowledge in the design analysis and dimensioning of structures. At the end of the module, students will be able to analyse the operation of real structures based on engineering drawings or schematic diagrams in case studies. They will be capable of solving and dimensioning structures possessing several degrees of static indeterminacy. They will be able to determine material characteristics that are useful in dimensioning, based on structural tests or laboratory experiments. They will be able to dimension simple concrete and steel structures.

Module Content Summary.

Revision of energy theorems and the principle of virtual work for calculating displacements in rod structures.

Use the Navier-Bernoulli assumption for compound-section calculations.

Methods for solving structures with several degrees of static indeterminacy.

Graphical method for trusses: Cremona diagram.

Case studies: start from a drawing, photo or description of a structure and carry out dimensioning by determining the relevant strength of materials models and loading possibilities.

Draw and use Mohr's circles for strains and stresses in order to make use of characterisation test results for dimensioning for stresses: how to use various criteria.

From Functions to Mechanisms

Department: *Mechanisms, Structures and Construction*

Year: *G1*

Category: *Discipline-based elective module*

Semester: *S6*

Duration: *32h*

Organisation: *Series of 4h lectures totalling 24h*

Individual work: 2 x 4h application of tools and methods for functional analysis of mainstream products.

Assessment: *Continuous assessment and summary report of unsupervised work.*

Specific rooms: *B05/B30 and B24/B28*

Prerequisites: *Curricular Harmonisation in Mechanics, Mechanics of Mechanisms*

Lecturer-in-charge: L. Patrouix

Lecturer(s): L. Patrouix, B. Tolba

Objectives.

One of the major roles of a business is to market goods and services that meet the needs of the end client. Through the use of specific tools (needs diagram, interaction diagrams, FAST creativity, FAST description, etc.), functional analysis makes it possible to structure the design or redesign approach so as to ensure that all the required functions are incorporated.

In this module, students will learn to use tools and methods of functional analysis to carry out design or redesign analyses of mechanical systems all by themselves. This is the main objective of the module.

Module Content Summary.

Tools will be introduced based on an example of a mainstream mechanism commonly found in the market.

Next, students will use these tools in a real case study with some help (tutorials) or entirely on their own (unsupervised work).

The overall module schedule is as follows:

- From needs to service functions (external analysis)
Needs diagram, interaction diagram
- From service functions to technical functions (internal analysis)
FAST creativity and FAST description
- From technical functions to technical solutions
FAST description, analysis of constructive solutions, etc.
Students will be shown the complementarity between various disciplines of mechanics featured in other modules.
- From technical solutions to master drawings
Functional specifications (Geometric Product Specifications – GPS)

Dynamic Simulation of Mechanical Systems

Department: *Mechanisms, Structures and Construction*

Year: *G1*

Category: *Discipline-based elective module*

Semester: *S6*

Duration: *32 h*

Organisation: *Lectures, tutorials (24h supervised, 8h unsupervised)*

Individual work: 8 h

Assessment: *Continuous assessment*

No. of students: *Maximum 16 students per room (2 lecturers if 32 students)*

Specific rooms: *B30 – B05*

Prerequisites: * *basic knowledge of Catia ("Systems Design")*

* *"Mechanics of Mechanisms" module*

Lecturer-in-charge: P. Hottebart

Lecturer(s): Y. Desplanques, P. Hottebart

Objectives.

Modelling systems in Mechanics of Non-Deformable Solids makes it possible to handle dynamic equilibrium problems with relatively few degrees of freedom in a way that is comparable to numerical approaches (finite elements) in Continuum Mechanics. Therefore, this is a highly efficient, fast and inexpensive method for understanding mechanical movements or actions in rigid multibody mechanical systems.

The objective of this module is to teach students to model mechanical systems based on CAD assemblies and use these models to the fullest by reflecting critically on the results with regard to modelling and the performance of numerical integration algorithms.

- Know the main numerical integration methods used in dynamics of non-deformable solid systems
- Know how to use numerical integration methods to solve problems with few degrees of freedom
- Learn about precision, stability and convergence problems
- Propose and implement static, kinematic or dynamic modelling of a mechanical system
- Validate a model
- Understand how modelling influences the computed results
- Understand how mechanical quantities influence various results
- Analyse the influence of calculation conditions on the validity of the results
- Propose a model to deal with shock and contact
- Implement structural optimisation

Module Content Summary.

- Numerical integration of differential equations of motion (SciLab software)
 - Solving the Cauchy problem
 - Euler method and modified Euler method
 - Runge-Kutta method: stability and convergence
 - Solving systems of second-order differential equations
- Parameterisation, closed kinematic chain, building 3D links/contacts, structural diagram, homokinetics,
- Input graphics software
- Processor / Computation
- Post-processing: output graphics software, shock management, forces in links
- Integration of physical phenomena by macrolanguage programming
- Teaching method:
 - lectures / tutorials in twos (CAD room)
 - introduction to software tools (guided exercises)
 - application to different case studies
- Software tools:
 - LMS / Motion Catia interfaced with Catia V5
 - SciLab code

Advanced CAD

Department: *Mechanisms, Structures and Construction*

Year: G2

Category: *Discipline-based elective module*

Semester: S7

Duration: 32 h

Organisation: *Lectures, tutorials (24h supervised, 8h unsupervised)*

Individual work: 8 h

Assessment: *Continuous assessment*

No. of students: *Maximum 16 students per room (2 lecturers if 32 students)*

Specific rooms: B30 – B05

Prerequisites: * *basic knowledge of Catia ("Systems Design")*

* *basic knowledge of kinematics ("Mechanics of Mechanisms")*

Intended audience: *Students who are interested in product design and who wish to become competent in using a CAD tool (CATIA V5).*

Industrial sectors: *Design and Engineering, Industrial Design*

Lecturer(s): P. Hottebart, L. Patrouix, D. Le Picart

Objectives.

- Use a CAD system as part of a concurrent approach to designing mechanical systems (Catia V5)
- Understand design methodology (Skeleton base, kinematics, data structure, etc.)
- As part of a design approach, choose and implement the most suitable model to achieve the desired functions
- Build a variational CAD model of a complete mechanical system
- Master the advanced functionalities of a CAD software: parameterisation, knowledge management, virtual mock-up, etc.
- Understand the connection between CAD and simulation

Module Content Summary.

- Advanced parts design: technological functions, advanced use of part assemblies, Boolean operations.
- Product categories, Catia/Excel interface for defining a parameterisation table, parts catalogue.
- Skeleton-based modelling
- Advanced assembly: benchmark modelling
- Assembly validation: virtual mock-up, animation (film), assembly-disassembly (DMU Fitting)
- Knowledge management, shape optimisation
- Surface design: basic concepts in surface design

Prototype Production for Project

Department: *Mechanisms, Structures and Construction*

Year: G2

Category: *Discipline-based elective module*

Semester: S7

Duration: 32h

Organisation: *Tutorials + lab sessions*

Assessment: *Continuous assessment*

Specific rooms: *Manufacturing workshop (turning, milling, drilling, CNC, metrology) + B23*

Prerequisites: *Design and Manufacture module*

Lecturer(s): D. Le Picart - L. Patrouix - Ph. Quaegebeur

Objectives.

Knowledge: This module aims to provide students with hands-on skills. It is especially intended for engineering students who have to carry out machining in the project component of their studies.

Skills: Choose the right machine for a one-off production. Choose the necessary tools. Choose the chuck and work-holder. Adjust these parts. Machine workpiece to given set of specifications.

Module Content Summary.

- Positioning and choice of work-holder
- Standard work-holder and machining configuration
- Meeting geometric specifications in turning and milling
- Influence of manufacturing methodology on compliance with specifications
- Different boring methods
- Creating particular functional surfaces
- Machining deformable parts
- Surface and cylindrical grinding
- Implementing a machining stage in a CNC machine
- Adjusting various parameters in a CNC machine
- Metrology and characterisation of machined surfaces

This module may be oriented in such a way as to better suit the needs of certain students.

Fabrication: from Virtual to Real

Department: *Mechanisms, Structures and Construction*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7*

Duration: *32 h*

Organisation: *Series of 4h tutorials and lab sessions totalling 24 hours*

Individual work: 8 h – Designing and modelling fabricated products

Assessment: *Continuous assessment*

No. of students: *maximum 16 students*

Specific rooms: *CAD room B05 or B30, sheet metal department of manufacturing workshop*

Prerequisites: *Core curriculum – Design and Manufacture, Systems Design.*

Lecturer(s): *A.L. Cristol, D. Le Picart, L. Patrouix*

Objectives.

Fabrication is an essential process in many areas: civil engineering, transport (rail, maritime, automotive, etc.), public works, production of machines, etc. This technique consists in the thermal assembly (welding) of simple component parts, most of which are obtained from semi-finished products (sheets, plates, tubes, extruded items, etc.). Such component parts can be obtained through a variety of procedures (casting, stamping, bending, machining, etc.).

This module aims to provide students with hands-on knowledge and skills in the design and manufacture of fabricated parts and structures (in order to produce prototypes for their project), as well as theoretical and experimental knowledge of the mechanisms involved in this type of production.

Module Content Summary.

- Introduction to standard components, the associated forming operations and the resulting mechanical characteristics.
- Mechanical testing, observation using microscopy in order to characterise and understand the mechanical behaviour of these products.
- Study of the behaviour of these materials during plastic deformation (bending, deep drawing, roll forming, etc.) related to the preforming of semi-finished products.
- Design and production methods based on industrial cases.
- Implementation of a complete production line.
 - a) Cutting (plasma, nibbling/punching, oxyfuel cutting)
 - b) Preforming (bending, deep drawing, machining, etc.)
 - c) Thermal assembly (MAG, TIG, resistance welding)
- Dimensional inspection of parts obtained
- Inspection of mechanical characteristics obtained (tensile testing, hardness testing, etc.)

Data Acquisition and Numerical Methods for Engineers

Department: *Mechanisms, Structures and Construction*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S7*

Duration:

Organisation: *Lab sessions and tutorials*

Assessment: *Reports and assignments*

Specific rooms: *Computer labs equipped with LABVIEW and FORTRAN software*

Prerequisites: (Core curriculum): *Mechanisms, Structures and Construction*

Lecturer(s): Franck Agostini, Mathias Brieu, Jean Gilibert

Objectives.

This module will take place during the second semester of G2.

By the end of the module, second-year students will have learnt the basic concepts of numerical methods for engineers as well as signal acquisition and processing. Throughout the module, they will familiarise themselves with sensors that are traditionally used in mechanics of materials, current tools for signal acquisition (Labview and other systems) and numerical data processing.

Module Content Summary.

Sessions:

- Lesson on numerical analysis and algorithmic methods
- Development of a numerical analysis tool (signal integration and/or differentiation)
- Data acquisition, introduction to Labview
- Using Labview to develop an acquisition tool
- Project

Finite Element Analysis in Systems Design

Department: *Mechanisms, Structures and Construction*

Year: G2

Category: *Discipline-based elective module*

Semester: S7

Duration: 32h

Organisation: *Lectures, tutorials (24h supervised, 8h unsupervised)*

Assessment: *Continuous assessment*

Specific rooms: B30 - B05

Prerequisites: Systems Design, Dimensioning of Systems, Structural Mechanics

Lecturer(s): Y. Desplanques, P. Hottebart, Ph. Quaegebeur

Objectives.

Knowledge:

- Know the basic theoretical concepts required for applying and using the finite element method.
- Know how to propose a suitable finite element model for dimensioning a component or a simple assembly: choice of 1D, 2D and 3D model, degree of interpolation, boundary conditions, mesh generation and links.
- Understand the relationship between CAD and finite element computation.

Skills:

- Use a finite element code in linear statics for the pre-project design of mechanical systems (pre-processing, computation, post-processing).
- Be able to assess the quality of a model, detect and understand the errors induced by the choice of numerical or physical model.

Module Content Summary.

The module will introduce students to a finite element code in CATIA V5 via a step-by-step approach. Each session will involve the analysis of industrial cases, which will occasionally be extended to unsupervised work. The module will begin with an introductory lecture on the finite element theory.

- Basic theoretical concepts, displacement approximation, finite element discretisation, solving numerical problems.
- Choice of numerical model, assessing the quality of a solution
 - Influence of the physical model
 - Geometric aspects
 - Importance of the type of material
 - Influence of boundary conditions (displacement and load)
- Modelling an assembly

Computer-Aided Analysis Tools for Systems Design

Department: *Mechanisms, Structures and Construction*

Year: G2

Category: *Discipline-based elective module*

Semester: S7

Duration: 32 h

Organisation: *Lectures, tutorials (24h supervised, 8h unsupervised)*

Individual work: 8 h

Assessment: *Continuous assessment*

No. of students: *Maximum 16 students per room (2 lecturers if 32 students)*

Room/Materials: B30 – B05

Prerequisites: *Mechanics of Mechanisms, Structural Mechanics, Systems Design, Dimensioning of Systems*

Lecturer(s): P. Hottebart, D. Le Picart

Objectives.

An industrial example will enable students to acquire the following:

- An understanding of the relationship between various design and dimensioning issues encountered throughout the design stage (examples with CATIA V5 software),
- Knowledge of how to adapt the design methodology to dimensioning objectives,
- A good grasp of various dimensioning tools:
 - Static validation, (LMS Virtual, RdM Le Mans)
 - Kinematic validation (e.g. Catia Kinematics),
 - Dynamic validation (e.g. LMS Virtual Lab),
 - Finite element computation: pre-processing, computation, post-processing (e.g. Catia Analysis)
 - Dimensioning a part
 - Dimensioning an assembly

Rapid Prototyping: from Virtual to Real

Department: *Mechanisms, Structures and Construction*

Year: G2

Category: *Discipline-based elective module*

Semester: S7

Duration: 32 h

Organisation: *Lectures, tutorials (24 h supervised, 8h unsupervised)*

Individual work: 8h

Assessment: *Continuous assessment*

No. of students: *Maximum 16 students*

Specific rooms: *B05 + rapid prototyping laboratory*

Prerequisites: *Design and Manufacture, Systems Design*

Lecturer(s): P. Hottebart - D. Le Picart - L. Patrouix - Ph. Quaegebeur

Objectives.

At the end of this 32h module, students will have learnt the purpose of rapid prototyping and how to integrate it in the numerical design chain.

They will be able to:

- Choose the appropriate technology for achieving the desired results.
- Identify the limitations of the main prototyping technologies.
- Implement key processes.
- Calculate the cost of a prototype.
- Correctly define the parameters of a virtual model.
- Define safety measures to be implemented during processing.

Module Content Summary.

- Purpose of prototyping in the numerical chain – Different types of prototypes
- Prototyping by addition of 2D layers
- Prototyping by duplication
- Prototyping by material removal
- Choosing a process based on desired material characteristics
- Metrological characteristics of various technologies
- Economic considerations in prototyping
- Reverse engineering

Durability of Geomaterials

Department: *Mechanisms, Structures and Construction*

Year: G2

Category: *Discipline-based elective module*

Semester: S8

Duration: 32h

Organisation: *lectures+tutorials+lab sessions*

Assessment: *continuous assessment*

Specific rooms: *computer labs and mechanical and civil engineering labs*

Prerequisites: *core curriculum modules: Materials Science, Structural Mechanics and Dimensioning of Systems*

Lecturer(s): C. Davy (lecturer-in-charge), F. Agostini, F. Skoczylas

Objectives.

Knowledge: know the industrial and scientific challenges related to the durability of geomaterials and real methods for assessing this durability (porosity, permeability, poromechanics, etc.). More specifically, students will learn the fundamental concepts of the very specific physics associated with the deterioration (or ageing) of cementitious materials. The vital role of water (in various forms) during the lifespan of this category of materials, which are the most widely used in the world, will be highlighted.

Skills: students will learn how to process raw experimental data obtained from mechanical (uniaxial compression), porosity and permeability tests, and how to analyse them in order to assess the durability of the geomaterial in question.

Module Content Summary.

- Basic knowledge of durability and geomaterials. Porous materials, poromechanics and transport properties.
- Cementitious materials: microstructure, composition, maturing, presence of water (structural or free form), loss of water, dimensional variations and cracking, evolution of transport properties, influence of water on macroscopic properties.

Example case studies: resistance to freezing/thawing, resistance to chemical aggression (acid rain, marine environment, etc.). Practical work will be carried out in this part of the module.

Unsupervised work: a case study on a structure possessing remarkable durability will serve as a guiding theme and will be the subject of an end-of-module oral presentation (to be done in pairs). This presentation will be based on bibliographic research work carried out during unsupervised sessions.

Experimental Methods in Mechanics of Materials

Department: *Mechanisms, Structures and Construction*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration:

Organisation: *4h lectures, tutorials, lab sessions.*

Assessment: *Based on lab reports*

Specific rooms:

Prerequisites: *Statics of Solids, Structural Mechanics.*

Lecturer(s):

Lecturer-in-charge: F. Agostini

Lecturers: F. Agostini, E. Berte, M. Brieu, A. El Bartali, J. Gilibert, P. Lecomte

Objectives.

This module will take place during the second semester of G2.

At the end of this module, second-year students will have acquired the basic concepts of experimental methods. Throughout the module, they will have the opportunity to familiarise themselves with sensors that are typically used in mechanics of materials, various mechanical tests and the geometrical constraints of the samples studied.

They should be able to:

- Describe (N2) a mechanical test
- Dimension (N3) the geometry of a test specimen
- Analyse (N4) a mechanical characterisation test

Module content summary and schedule.

- Concepts of mechanical testing - Concepts of sensors
- Designing and dimensioning test specimens
- Carrying out mechanical testing (characterising elasto-plastic behaviour, non-linear elastic behaviour, friction, etc.)

Combined Experimental-Modelling Approach

Department: *Mechanisms, Structures and Construction*

Year: G2

Category: *Discipline-based elective module*

Semester: S8

Duration: 32h

Organisation: *4h seminars totalling 24h, 8h unsupervised work*

Assessment: *Lab reports and reports on unsupervised work*

Specific rooms: *B24 or B28*

Prerequisites: Basic knowledge of Continuum Mechanics

Lecturer(s): F. Agostini, P. Lecomte, F. Skoczylas, JF. Witz,

Objectives.

Knowledge:

Models that are used to describe the behaviour of materials sometimes contain parameters that are not attainable through direct measurements. Thus, it is often necessary to resort to special identification methods.

The aim of this module is to introduce methods for modelling and measuring the mechanical behaviour of materials and structures, as well as specific identification techniques for determining all the parameters of a model – even those that cannot be measured by direct methods.

Skills:

This module aims to introduce specific techniques and tools relating to experimental measurement, mechanical testing and modelling to meet two major needs: identifying physical quantities and comparing simulation and/or modelling results with experimental ones.

Module Content Summary.

The fundamental concepts of continuum mechanics will be revised. Numerical simulation based on the finite element method will be briefly introduced.

This theoretical part will be supplemented by practical learning sessions on experimental methods and specific tools for kinematic field measurements.

There will be lab work on numerical simulations and mechanical testing, which will enable students to compare experimental and numerical results and study the behaviour of materials (metallic, concrete) subjected to complex loadings.

Finally, the hydromechanical behaviour of concrete will be studied in order to highlight the influence of the choice of model on the interpretation of the measured quantities.

Modelling and Creation of Skew Surfaces

Department: *Mechanisms, Structures and Construction*

Year: G2

Category: *Discipline-based elective module*

Semester: S8

Duration: *32 hours*

Organisation: *Series of 4h seminars totalling 24h supervised and 8h unsupervised sessions*

Assessment: *Continuous assessment*

Specific rooms: *room B05 or B30 – Mechanical production workshop*

Prerequisites: *Core curriculum modules*

Lecturer(s): D. Le Picart, L. Patrouix

Objectives.

At the end of this 32h elective, students will be able to:

- give the basic mathematical definition of skew curves and surfaces (Béziers, Spline, Nurbs, etc.),
- implement a design methodology for skew surfaces,
- explain the purpose of rapid prototyping in product validation,
- know how to machine skew surfaces,
- implement reverse engineering methodology.

Module Content Summary.

- Introduction to the theory of skew surfaces (mathematical definition, purpose, etc.),
- Using complex surfacing modules in CATIA V5,
- Application to an industrial part,
- Producing this part in rapid prototyping for design validation,
- Using the CATIA V5 machining module for creating machining paths,
- Visualising machining operations in a CNC machine,
- Using a 3D laser scanner; software processing of a scatter plot.

Science of Friction

Department: *Mechanisms, Structures and Construction*

Year: G2

Category: *Discipline-based elective module*

Semester: S8

Duration: 32h

Organisation: *4h lectures/tutorials - 20h lab sessions – 6h unsupervised work – 2h assessment*

Assessment: *Continuous assessment*

Specific rooms: *experiments lab and SEM room in Mechanics of Materials, Materials Science labs, rooms B30/B05.*

Prerequisites:

Lecturer(s): X. Boidin, A.-L. Cristol, Y. Desplanques

Objectives:

Friction and wear phenomena occur in virtually all mechanical systems. They are often the cause of malfunctions and are detrimental to a system's reliability, performance and lifespan, and may also harm the environment. Such phenomena are the result of complex multiphysical and multiscale interactions that occur on contacting solid surfaces. It would be too simplistic to reduce friction and wear to mere material properties, and it is not surprising to find that many existing phenomenological models used to describe them (e.g. Coulomb's law of friction or Archard's law of wear) are easily lacking in one way or another.

The objective of this elective module is to enable students to better understand phenomena related to friction and wear, and to get a grasp of their multiphysical and multiscale nature. After a presentation of the various theories in *Tribology* (science of friction and wear: from *tribein* "to rub" and *logos* "speech"), a large portion of the module will be devoted to the study of relevant phenomena via practical work, especially the influence of surfaces and coatings on the tribological properties of contacting solids. Numerical modelling of contact problems will be introduced and used as a tool for understanding the mechanisms involved.

Module content summary:

- Introduction to the tribology of surfaces, empirical laws and two- and three-body friction theories. Concepts of tribological systems and circuits. Wear mechanisms, wear laws and maps. Tribological behaviour: bulk materials (metals, ceramics, polymers, composites) and surface treatments. (4h lectures/ tutorials)
- Numerical modelling of contact using finite elements: interaction between solids, choice of an interface model. Influence of surfaces, coatings and their properties. (4h lab work)
- Friction tests: choice and influence of experimental configuration, conducting tests on pin-on-disc test tribometer. (4h lab work)
- Braking tests: determining test conditions, setting up instrumentation (thermocouples, infrared cameras, pyrometers), choice and influence of experimental configuration, conducting tests on pin-on-disc tribometer. (4h lab work)
- Surface treatments for friction and wear: implementation (surface hardening by torch, case hardening, electrolytic nickel plating), characterising surface treatments (optical microscopy, SEM/EDX, optical profilometry) and friction testing. (8h lab work)

Process-Property Relationships

Department: *Mechanisms, Structures and Construction*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *24h (6 x 4h) seminars*

Assessment: *Continuous assessment*

Specific rooms: *Metrology Lab, Sheet Metal Lab, Materials Science Lab, SEM, B24*

Prerequisites: *Core curriculum – Design and Manufacture*

Lecturer(s): A-L Cristol, P. Lecomte, C. Niclaeys.

Objectives.

There is a very close relationship between manufacturing/assembly processes and the properties of the parts concerned. On the one hand, the material – and therefore the associated properties – of the part is one of the things that dictates the type of process to be used. On the other hand, the process, in turn, influences the properties of the part. How do operations such as oxyfuel cutting, welding, bending etc. modify a part locally? Are the core and surface microstructures of a cast part the same? During milling, how does the feed rate affect the surface condition of the part? Does a rolled sheet have the same mechanical strength in the rolling and transverse directions?

By the end of this module, students will be able to answer all these questions and more. They will have acquired theoretical knowledge about the influence of processing techniques on properties and will know how to identify process-induced modifications by means of testing and characterisation techniques. Teaching will be based on case studies.

Module Content Summary.

- Choice of process according to the properties of the part,
- Implementation of various manufacturing and assembly processes,
- Preparing samples for observation and characterisation,
- Observing microstructures,
- Measuring properties (tensile behaviour, hardness, surface roughness, etc.),
- Interpretation of results and conclusions on selected processes,
- Individual study of a process and its influence on mechanical properties.

Quality and Production Control

Department: *Mechanisms, Structures and Construction*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation: *24h comprising lectures, tutorials and lab sessions*

Assessment: *Continuous assessment*

Specific rooms: *Manufacturing workshop, metrology workshop, tutorial room, etc.*

Prerequisites: *Mechanisms, Structures and Construction*

Lecturer(s): *C. Niclaeys, P. Quaegebeur, P. Hottebart*

Objectives.

Quality is fast becoming an increasingly significant aspect of any business. Standards and certifications are now perceived as a guarantee of quality. The aim of this elective module is to introduce students to the notion of quality by examining the different tools for production control and the main industrial certifications. Teaching will be based on industrial case studies mainly relating to dimensional metrology.

Module Content Summary.

- Master the use of several quality control tools
- Know the different types of control
- Interpret the different standards (ISO 9000, ISO 9004, ISO 14001, etc.)
- Know the different certification stages and procedures
- Know how to use various production control tools (Kanban, SPC, etc.)
- Application to dimensional metrology in industrial cases

Automotive Technologies and Design

Year: G2

Category: *Discipline-based elective module*

Semester: S8

Duration: 32h

Organisation: *Series of 4h seminars totalling 24h – 8h unsupervised work*

Assessment: *Continuous assessment + report on unsupervised work*

No. of students: 32

Specific rooms: *Rooms B24/B28*

Industrial sectors: *Automotive design and engineering*

Prerequisites: *Curricular Harmonisation in Mechanics, Systems Design, Dimensioning of Systems*

Lecturer(s): X. Boidin, P. Dupont, P. Hottebart, D. Le Picart

Objectives.

The objective of this 32h elective module is to achieve the following:

- Analyse and understand the various constituent units of a car
- Analyse the power transmission chain between the engine and wheels
- Study the technology behind the different constituent units of vehicles
- Characterise a heat engine with a test bench
- Read an assembly drawing
- Determine the main criteria for car design and dimensioning

Module Content Summary.

- Presentation of the key component units of power transmission systems in cars. Overall layout of power transmission, operation and role of the various components. Adapting a transmission and evaluating vehicle performance.
- Analysing the technical solutions in a heat engine.
- Study of the different types of automatic transmission units: traditional coupler/converter, dual-clutch or continuously variable systems. Assembly/disassembly, operation, technology, gear shifts, etc.
- Vehicle handling and suspension, role of Citroën's hydropneumatic suspension.
- Study of differential, operating principle, different types: gears, limited slip (viscous coupling or Torsen).
- Write a technical document in groups of four or five (unsupervised work). Subject: a vehicle component unit of their choice (e.g. sequential gearbox, clutch, pneumatics, design, etc.).

Failure of Materials: Fatigue and Reliability of Structures

Department: *Mechanisms, Structures and Construction*

Year: G2

Category: *Discipline-based elective module*

Semester: S8

Duration: 32h

Organisation: *Lectures, tutorials, seminars, unsupervised work*

Assessment: *Continuous assessment*

Specific rooms: *General-purpose room (lectures) & Mechanics of Materials experiments lab and SEM room + Materials Science labs (lab sessions)*

Prerequisites:

Lecturer(s): A. El Bartali, P. Lecomte, C. Niclaeys, Ph. Quaegebeur

Objectives.

The objective of this module is to increase students' awareness of the in-service characteristics of industrial materials and their impact on the dimensioning of structures. The presence of microdefects and cracks and the in-service temperature are all important considerations in designing components for high reliability or specific lifespans.

Module Content Summary.

"Are these cracks in the aircraft wing cause for concern?"

"Why did my lightbulb only last 1000 hours?"

To answer these questions (and many more), this elective module will cover the following:

- The different types of failure and the associated micromechanisms.
- Cracking and crack propagation.
- Fatigue failure.
- Structural design for withstanding fatigue loading.
- Dimensioning for fatigue.
- Creep failure.

In this module, basic concepts will be covered in lectures. However, as far as possible, they will be supplemented by the following:

- case studies where the student will be put in the shoes of an expert.
- practical work involving different methods for observing the structures of materials and characterising their properties via mechanical testing.

Geotechnics: from Basics to Professional Applications

Department: *Mechanisms, Structures and Construction*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32 h*

Organisation:

Assessment:

Specific rooms:

Prerequisites: no prerequisites (usual post-preparatory class standard). Interest in civil engineering.

Lecturer-in-charge: Z. Lafhaj

Lecturer(s): F. Necki (LRPC), Z. Lafhaj

Objectives.

Knowledge:

Understand the fundamental principles and laws of geotechnics. Learn how to choose and interpret physical tests in soil mechanics. Application to the design and dimensioning of structures.

Skills:

Be able to establish a geotechnical survey campaign. Be able to interpret key in situ or laboratory tests that are required for dimensioning structures in geotechnics. Be able to think and act like an engineer working on a real geotechnical project.

This module is aimed at highly motivated students who wish to go beyond the basics of civil engineering, and who are particularly interested in geotechnics.

Module Content Summary.

- Definition, nature and classification of soils (clay, silt, sand, etc.)
- Stresses in large massifs (total and effective stress, Boussinesq principle)
- Water flow in soils (Darcy's law, permeability, suction)
- Problems associated with the deformability of soils (consolidation, calculating soil compaction)
- In situ tests (probing, non-destructive testing, destructive testing, pressure meter, penetrometer)
- Shallow foundations, deep foundations, retaining structures, active and passive earth pressures,
- Standards in geotechnics, Eurocode 7.

Teaching methods

- Alternation between theoretical and practical work.
- Simulations with real cases (supervised by an industry expert)
- Application to the different stages of a real project
- Calculating shallow- and deep-foundation dimensions, calculating compaction

Continuum Mechanics: Linear Elasticity

Department: *Mechanisms, Structures and Construction*

Year: *G2*

Category: *Discipline-based elective module*

Semester: *S8*

Duration: *32h*

Organisation: *lectures + tutorials*

Assessment: *continuous assessment*

Specific rooms: *none*

Prerequisites: *core curriculum modules in Statics of Solids, Structural Mechanics*

Lecturer(s): *C. Davy (lecturer-in-charge), F. Skoczylas, M. Brieu, A. Leblanc*

Objectives.

Knowledge:

By the end of this module, students will have acquired supplementary theoretical knowledge for dealing with relatively complex problems in mechanics of deformable solids and structures. The theoretical approach covered in this module underlies the finite element methods and tools that are commonly used in structural design analysis (these methods and tools themselves are taught in other complementary discipline-based electives).

Skills:

Students will learn how to:

- Describe (N2) and use (N3) constitutive equations (linear elasticity) in isotropic and/or anisotropic behaviour,
- Analyse (N4) a structural problem and define (N4) the associated continuum mechanics problem,
- Analyse (N3) the resulting stress and strain tensors,
- Dimension (N3) and analyse (N4) a complex predefined structure.

Module Content Summary.

- (2 sessions) Tensor calculations: assimilation of concepts covered in lectures (Einstein summation convention, Kronecker index, conservation laws); exercises
- (1 session) Concept of stress and strain tensors; exercises
- (1 session) Elasticity and constitutive equations. Identification of materials: application to the case of an orthotropic material, a cylindrical tube subjected to internal and external pressure.
- (1 session) Plane problems; Airy functions; exercises.
- (1 session) Variational formulation, well- or poorly defined problems and concept of the existence and the uniqueness of a solution to a problem in mechanics.
- (1 session) Energy methods & principle of virtual work; approximate solutions; exercises
- (1 session) Case of large strains; Lagrangian and Eulerian approaches.

Heterogeneous Materials

Department: *Mechanisms, Structures and Construction*

Year: G2

Category: *Discipline-based elective module*

Semester: S8

Duration: *32 hours (of which 8h unsupervised)*

Organisation: *Lectures (16h), tutorials (8h), exam (2h)*

Assessment: *continuous assessment (unsupervised work) and final exam*

Specific rooms: *no specific rooms*

Prerequisites:

- Statics of Solids
- Structural Mechanics

Lecturers: Frederic Skoczylas, Bernard Paluch, Pauline Leconte, Mathias Brieu.

Objectives.

This module will take place during the 2nd semester of G2.

By the end of the module, 2nd year students will have acquired basic knowledge of heterogeneous materials. They will have learnt the unique characteristics of heterogeneous materials, their origins and/or how they are obtained, as well as techniques for characterising and modelling their behaviour within an elastic and linear framework.

Module Content Summary.

Sessions:

- 1) 4h lecture : - 2h production and processing of industrial composites
- 2h modelling of linear elastic behaviour of heterogeneous materials
- 2) 4h lecture : - 2h production and processing of industrial composites
- 2h modelling of linear elastic behaviour of heterogeneous materials
- 3) 4h lecture : - 2h production and processing of industrial composites
- 2h modelling of linear elastic behaviour of heterogeneous materials
- 4) 4h lecture : - 2h definition and characterisation of a natural composite: wood
- 2h definition and characterisation of composites used in civil engineering: concrete
- 5) 4h lecture : - 2h definition and characterisation of a natural composite: wood
- 2h definition and characterisation of composites used in civil engineering: concrete
- 6) 4h lecture : - 2h definition and characterisation of a natural composite: wood
- 2h definition and characterisation of composites used in civil engineering: concrete
- 7) 8h unsupervised work: Designing a composite structure

Assessment:

At the beginning of the unsupervised part of the module, students will be required to take a proficiency test (MCQ). The unsupervised component will be assessed.

Department of Business Studies

Working Culture and Communication Skills

Department: *Business Studies*

Year: *G1*

Category: *Core curriculum*

Semester: *S6*

Duration: *32 h/student*

Organisation:

- *INTERPERSONAL COMM: 2 X2h tutorial /2h unsupervised work / 2X4h practical work / 2h tutorial / 3h unsupervised work*
- *ARGUMENTATION: 2h tutorial / 3h unsupervised work / 2X4h tutorial*

No. of students: *tutorials per entire class / practical work per ½ class*

Assessment:

- *Simulated interviews prepared in twos as part of unsupervised work. Presentation of a realistic professional situation and analysis of data for an interpersonal problem. Conflict resolution per half class. 8h practical work and 2h unsupervised work (in twos).*
- *Group work: based on research carried out in groups of four, sift through information to implement a communication strategy that meets the specific constraints of the company chosen by the students. 3h unsupervised work and 2h oral presentation per half class.*

Specific rooms: *Room with overhead projector, video projector and Web access*

Lecturer(s): Laurence Cayron, Paul Becquart

Subject area 1: interpersonal communication.

Objectives.

Raise awareness of the difficulties that characterise certain interpersonal relationships in the professional setting, especially managerial environments.

Knowledge:

Presentation of the Palo Alto School and transactional analysis.

Skills:

Handling a tricky or tense management situation.

Module schedule and module content summary.

Role play relating to a real problem presented by the lecturer. Collective reflection on the difficulties in field management.

Presentation of the Palo Alto School. Systemic approach. Analysis tools. Presentation of transactional analysis. 4h tutorial (entire class, preferably in two 2h sessions).

Subject area 2: argumentation.

Objectives

Develop a set of arguments in the context of team or individual work.

Prerequisites: basic knowledge of the sociology of organisations (covered in semester 1, before work placement). Taylorism, Fordism, Toyotism, corporate culture, expansion of service sector, outsourcing, offshoring/relocation.

Knowledge:

Company communication plan and strategy.

Skills:

Know how to select information for better communication. Know how to communicate about change. Introduction to change management.

Organisation:

Communication plan and strategy. Corporate communication, event planning, product communication. Media planning, corporate identity, copy strategy. 2h tutorial (entire class).

Individual work:

3h unsupervised work and 8h presentation (half the class at any one time). Review of documents on a management method, if possible one observed during work placement. Simulation of change management. Individual presentation (about ten minutes) followed by an open discussion with students in the same half class.

Sociology of Organisations

Department: *Business Studies*

Year: *G1*

Category: *Core curriculum*

Semester: *S5*

Duration: *34 h/student - (10h lectures + 12 unsupervised work + 6h tutorials + 2h exam)*

Organisation: *2h lecture + 2h tutorial / 2h lecture + 4h unsupervised work + 2h tutorial / 2h lecture + 4h unsupervised work + 2h tutorial / 2h lecture + 4h unsupervised work + 2h tutorial / 2h lecture / 2h exam.*

Individual work: 6 h

Assessment:

Continuous assessment

- *Quality of concept maps submitted and presented at the end of PBL series*
- *Attendance and participation during PBL sessions*

Final exam

No. of students:

Lectures given to entire class or per half class

Tutorials in parallel: 2 tutorial groups in parallel.

Specific rooms:

Video projector + speakers for lectures (stages and restructuring)

Wi-fi internet access: 60 connections per lecture theatre at the end of stage 1

If possible: lecture theatre with windows equipped with blinds to block out lights for the projection of films

Prerequisites: none

Lecturer(s): Rémi Bachelet, Claire Belart, Alexandre Lene, (ATER) Temporary Teaching and Research Fellow

Objectives.

Manage one's e-identity and e-reputation. Explain what constitutes a social network. Understand the basics of structural analysis. Identify the key issues related to popular social networks.

Concept of organised action and associated metaphors. Distinguish between the various trends that contributed to the theory of organisations: scientific management approach, human relations approach, sociotechnical approach, contingency theory, economic and neo-institutional approaches.

Concepts of professional identity and how it is related to corporate culture. Strategic diagnosis: challenges, power and grey areas.

Auditing tools/recommendations: Flow charts, procedure analysis, sociograms.

Module Content Summary.

- Lesson plan
 - Stage 1: Online identity and social networks
 - Stage 2: Changes in the workplace
 - Stage 3: Corporate culture and human resources
 - Stage 4: Analysis methods of organisations
 - Recapitulation/restructuring

Each stage comprises:

- an introductory lesson accompanied by a documentary (2h in lecture theatre),
- a PBL group session (4h unsupervised work),
- the results of which are presented by each team (2h tutorial in groups of 30)

Economic Sciences

Department: *Business Studies*

Year: *G1*

Category: *Core curriculum*

Semester: *S6*

Duration: *32 h per student - (12h lectures + 8h unsupervised work + 10h tutorial + 2h exam)*

Organisation: *2h lecture (entire class) + 2h lecture (½ class) / 2h unsupervised work + 2h tutorial / 2h unsupervised work + 2h tutorial / 2h lecture (entire class) + 2h lecture (½ class) + 2h lecture (½ class) / 2h unsupervised work + 2h tutorial / 2h unsupervised work + 4h tutorial / 2h exam*
Individual work: 8h

Tutorial 1 and tutorial 2 schedules: *2 x 2h tutorial slots and not 2h unsupervised work +2h tutorial in the same morning/afternoon – Minimum of one-day interval between unsupervised work and tutorial.*

Assessment:

Tutorial: each accounts for 15% of final marks. MCQ at start of module to test proficiency.

Final exam: 40% of marks; MCQ: the questions will cover concepts learnt in lectures and tutorials. No books/materials will be allowed. Invigilated exam.

No. of students: *Lectures given to entire class or per ½ class*
Tutorials: in tutorial groups

Room/Materials: *Lectures: Video projector + microphone; wi-fi access*
Tutorials: Video projector + wi-fi access

Prerequisites: none

Lecturer(s): Dominique Frugier (lecturer-in-charge), Rémi Bachelet, Djamel Messaoudi, Joël Ferri, Stéphane Minetater

Objectives.

This module in economics is intended as an introduction to basic economic concepts that are required for understanding vocabulary related to economics, the corporate environment, key economic mechanisms, economic situations, forecasts and schools of thought. This will be accompanied by an introduction to financial markets.

Module Content Summary.

- Lesson plan and table of contents:
 - Introductory chapter: What is the economy?
 - Chapter 1: Microeconomics, markets.
 - Chapter 2: Macroeconomics, economic policies.
 - Chapter 3: Economic situations, inflation, unemployment.
 - Chapter 4: Currency.
- Content of tutorials
 - Tutorial 1: case study: comparative employment policies; preparation for this tutorial will be carried out during unsupervised work on employment theories.
 - Tutorial 2: case study: China's development; preparation for this tutorial will be carried out during unsupervised work on growth theories.
 - Tutorial 3: case study: the petroleum economy; preparation for this tutorial will be carried out during unsupervised work based on the economics and geopolitics of the petroleum industry.
 - Tutorial 4: Financial discounting; calculating Net Present Value, using these criteria.

Management

Department: *Business Studies*

Year: G2

Category: *Core curriculum*

Semester: S7

Duration: *48h / student*

Organisation: Split into four modules:

1. *General Business Policies and Business Strategies* (24h)
2. *Marketing* (12h)
3. *Introduction to Business Creation – Negotiation* (4h)
4. *Negotiation* (6h)

Assessment: *continuous assessment + final written assessment* (2h)

General Business Policies and Business Strategies

Duration: *24h / student*

Prerequisites: none

Lecturer(s): Dominique Frugier (lecturer-in-charge), Abdelkader Bousnane, Yves Selliez, Nathalie Delforge, Tanguy Bricout, Dominique Boudin, Jérôme Despatis, Nordine Benkeltoume, Marie Vaillant Vanaerde, Claude Surin.

Objectives.

The main focus of this module is on general business policies and business strategies.

Module Content Summary.

Lesson plan:

- | | |
|--|---|
| 1 Operational decisions and strategic decisions | 7 Competitive structure within a sector |
| 2 Learning curve | 8 Generic competitive strategies |
| 3 Product life cycle | 9 Key strategic manoeuvres |
| 4 Strategic segmentation | 10 Technology and strategy |
| 5 Portfolio management: strategic tables | 11 Marketing strategy |
| 6 Portfolio management: skills transfer and activity sharing | 12 Strategic foresight |

Content of tutorials

4 case studies on the following topics:

- 1) Strategic decisions and functional decisions; strategic segmentation.
- 2) Business portfolios.
- 3) Competitor analysis.
- 4) SME strategic diagnosis.

Marketing

Duration: 12 h / student

Assessment: Presentation of case study at the end of tutorial series

Prerequisites: None

Lecturer(s): Dominique Frugier (lecturer-in-charge), Alain Millecamps, Philippe Leleu

Objectives. Introduction to marketing

Module Content Summary.

Lesson plan

- I: Introduction
- II: Product policy
- III: Pricing policy
- IV: Distribution policy
- V: Communication policy
- VI: Planning and marketing analysis

Negotiation

Duration: 6h / student

Assessment: submission of tutorial assignment (prepared as part of unsupervised work) for final assessment

Prerequisites: None

Lecturer(s): Thierry Fricheteau (lecturer-in-charge), Esther Joly, Claire Belart.

Objectives: Approach to negotiation strategies

Module Content Summary.

Presentation of 6 phases in Win-Win negotiation,

- Initiation phase:
- actions, desired objectives, synchronisation, positive correction, power of silence, feedback,
- Discussion phase:
- actions, desired objectives, honing language, golden rules,
- Strategic phase:
- actions, desired objectives, introduction to strategic analysis model, influence, power,
- Convergence phase:
- actions, desired objectives, golden rules, assertiveness, tactics (issues and people involved),
- Conciliatory phase:
- actions, desired objectives, garnering support, concessions, qualities of a good negotiator,
- Signing phase:
- actions, desired objectives, successful Win-Win negotiation.

Introduction to Business Creation

Duration: 6 h / student

Assessment: Assessment of assignments

Prerequisites: None

Lecturer(s): Dominique Frugier (lecturer-in-charge), Françoise Aldebert.

External guest speakers: Young entrepreneurs

Objectives: Introduction to business creation

Module Content Summary.

Main topic: how to find and validate an idea for creating a business. Introduction to marketing innovation.

Secondary topic: experiences of entrepreneur guest speakers.

Law

Department: *Business Studies*

Year: *G2*

Category: *Core curriculum*

Semester: *S7-S8*

Duration: *32 h/student*

Organisation: *8 x 4h lectures*

Assessment: *Two written assessments. One mid-module test and one final exam.*

Specific rooms: *no specific requirements*

Prerequisites: *none*

Lecturer(s): *Hervé Lekens, Dominique Trousseau, Yannick Carney.*

Objectives.

Knowledge:

Introduction to law (legal standards, judicature, notions of procedures) and essential aspects of the law of obligations, labour law and commercial law. Facilitate integration and advancement in the business world.

Skills:

Thorough grasp of the legal environment of businesses, ability to understand common legal situations, search for relevant legislative texts and case law, propose or make decisions.

Module Content Summary.

Introduction to Law: 8 h

Concept and role of the Law, the different branches of law

- **Legal standards: 4 h**

The Constitution + glimpse into major national institutions

Key international treaties

 The ECHR

 EU treaties and major European institutions

 Secondary EU legislation: Bylaws, Directives, Rulings,

National laws and orders

Bylaws (decrees, orders)

Collective agreements

Case law, customs, tenets

- **Judicature: 4 h**

- The courts

Judicial courts and administrative courts

Disputes tribunal

Out-of-court settlement: arbitration

- The actors

The parties

Public prosecutors and presiding judges

Officers of the court (lawyers and bailiffs)

- Notions of procedures

Civil procedure: Proof, contradiction, time limit for lodging appeals

Criminal procedure: criminal action, prescriptions, civil action

Law of obligations: 8 h

- **Legal system governing contracts**
 - Conditions of formation
Consent and defects, Capacity
Object, Cause
 - Effects of a contract
Binding power
Privity of contract
Contractual liability (conditions and compensation for loss or damage)
- **Tort liability**
 - for wilful misconduct
 - for misfeasance or negligence
- **Specific liabilities of economic operators**
 - Latent defects
 - Defective products
 - Liability with regard to the competition
- **Liability of managers/directors**
 - towards partners/associates
 - towards employees
 - towards public services

Labour Law: 8 h

- **Recruitment 2 h**
 - Concept of employment contract: service, remuneration, hierarchy
 - Recruitment formalities and terms
 - Exclusivity and non-compete clauses
- **Carrying out the employment contract: 4 h**
 - Trial period
 - Working hours and workplace
 - Salary
 - Leave
 - Disputes
- **Breach of employment contract: 2 h**
 - Resignation and conventional breach
 - Dismissal for professional misconduct
 - Redundancy

Commercial law: 4 h

- **Businesses**
 - Material aspects: Equipment, goods
 - Non-material aspects: Clientele, trade name, corporate name, lease rights and industrial property rights: patents, brands, industrial designs and models
- **Commercial lease**
- **Corporate law**
 - General concepts of companies
Components of company contracts
Company character
Classification of companies (civil, commercial)
 - Overview of different companies

European internal market law: 4 h

- **Free movement of goods**
 - Prohibition of financial obstacles to exchanges (customs and fiscal weapons)

- Prohibition of quantity restrictions and other restrictions
- Principle of mutual recognition
- Authorised state interference (morality, public health and safety, etc.)
- Harmonisation of legislation (European standardisation)
- **Free movement of workers**
 - Beneficiaries
 - Their rights
 - Authorised state interference (certain positions in the public sector that are only open to nationals, law and order, etc.)
- **Law of establishment** (industrial, cottage and commercial activities, self-employment)
 - Primary establishment
 - Secondary establishment (subsidiaries, branches, etc.)
 - Terms of operation
 - Authorised state interference
- **Free provision of services** (industrial, cottage and commercial activities, self-employment)
 - Scope of application: Transnational provision of services (temporary in nature)
 - Terms of operation
 - Authorised restrictions
- **Free movement of payments and capital**
 - Vital distinction between payments and capital
 - Late implementation of the complete liberalisation of capital in the EU: 01 July 1990
 - Capital movements from or out of the EU
 - Measures for protecting state interests
 - Fight against tax evasion (tax-return system, communication between tax administrations, criminal penalties)
 - Measures related to Common Foreign and Security Policy

Market Finance

Department: *Business Studies*

Category: *Discipline-based elective module - [13/02/2012-14/04/2012 – Wednesdays 8h00-12h15]*

Semester: *S6*

Duration: *32 h*

Organisation: *4h lecture/ 4h unsupervised work / 2h tutorial + 2h lecture / 4h lecture / 2h lecture + 2 h unsupervised work / 2h unsupervised work + 2h tutorial / 2h lecture+ 2h practical work/ 2h unsupervised work + 2h tutorial*

Individual work: *5 h*

Assessment: *each session will be assessed*

No. of students: *Maximum of 24 students (6 groups of 4)*

Room/Materials: *sessions 7 and 8: 24 workstations*

Lecturer(s): Rémi Bachelet – Augustin Mouze

Objectives.

Introduction to mathematical finance and how financial markets operate. We will also discuss professional opportunities for engineers in financial markets and the associated study and career paths.

During this module, students will gain basic knowledge of how financial markets work in the context of globalisation (part 1), learn how to produce pricers using mathematical finance (part 2) and carry out market simulations (part 3). These sessions will be conducted using JessX, an OpenSource software created and developed at Centrale Lille <http://JessX.net>

Session schedule.

Session 1: Challenges in the world of finance: introduction to globalisation

Session 2: 4h unsupervised work on globalisation and finance

Session 3: oral presentation on globalisation + 2h lesson on mathematical finance

Session 4: 2h lesson on mathematical finance + 2h lesson on financial products

Session 5: 2h lesson mathematical finance + 2h unsupervised work Black & Scholes

Session 6: 2h unsupervised work Black & Scholes + oral presentation on mathematical finance module

Session 7: 2h intro to experimental finance + 2 h practical work

Session 8: 2h unsupervised work on experimental finance + 2h experimental finance

Department of Modern Languages

English

Department: *Modern Languages*

Year: *G1*

Category: *Core curriculum*

Semester: *S5-S6*

Duration: *48H (24H in S5 + 24H in S6)*

Organisation: *Series of tutorials (1H30 per week) totalling 48H in S5 / S6*

Individual work: *Written assignments + research/preparatory work over two semesters*

Assessment: *Continuous assessment (homework and in-class assignments + oral presentations + class participation)*

No. of students: *maximum 18*

Specific rooms: *Language rooms with audiovisual equipment + multimedia language lab*

Prerequisites: *no prerequisites (usual post-preparatory class standard). Students will be required to take a placement test at the beginning of S5 in order to group them according to level.*

Lecturer(s): S. Davies -- A. Delame -- V. Dziwniel – J-J Le Yeuc'h – N. Quayle - S. Roskell - External guest speakers.

Objectives

- Reinforce previously acquired oral and writing skills, with particular emphasis on communication aspects. The small group size (18 students) lends itself to such an approach.
- Deepen understanding of English-speaking cultures (literature, social problems, politics, geography, etc.) through a variety of materials (videos, radio broadcasts, articles, etc.).
- Familiarise students with the English-speaking business world with the help of appropriate reading material ("Market Leader Upper Intermediate", Pearson Longman) that each student receives at the start of G1.
- Introduction to the TOEIC test (Test of English for International Communication), which they will sit in S7.

Module Content Summary.

In addition to several core topics, each lecturer will contribute specific knowledge from his or her own field of specialisation. Besides grammar, which remains the foundation of all language instruction, the following key areas will be covered:

- Analysis and interpretation of documents (videos, audio materials, news articles, etc.) on various aspects of the civilisation and culture of the countries involved.
- Writing different types of documents that are specific to the engineering profession (correspondence, reports, scientific and technical articles, curriculum vitae).
- Familiarisation with problems specific to "scientific" language (syntactic and lexical).
- Action-oriented approach through role play/group work simulating various professional situations.
- Case studies of various professional situations.
- Introduction to the TOEIC test (Test of English for International Communication).

Second Language

Department: *Modern Languages*

Year: *G1*

Category: *Core curriculum*

Semester: *S5-S6*

Duration: *48H (24H in S5 + 24H in S6)*

Organisation: *Series of tutorials (1H30 per week) totalling 48H in S5 / S6*

Individual work: *Written assignments + research/preparatory work over 4 semesters*

Assessment: *Continuous assessment (homework and in-class assignments + oral presentations + class participation)*

No. of students: *minimum 15 / maximum 18*

Room/Materials: *language rooms with audiovisual equipment + multimedia language lab*

Prerequisites: *no prerequisites (usual post-preparatory class standard)*

Lecturer(s): A. Branco – P. Hilleke -- External guest speakers.

Objectives.

Students may choose German, Spanish, Japanese, Chinese or Portuguese as a second language. For non-French students admitted to double-degree programmes, the compulsory second language is French as a Foreign Language. Japanese classes will be held in the evenings at the ENSC de Lille.

Both beginners and non-beginners are accepted. However, there must be a minimum of 15 students per class.

The main objectives are the following:

- Gain and/or further knowledge of basic (syntactic) structures with the help of various materials (videos, radio broadcasts, articles, etc.).
- Familiarisation with the various aspects of the civilisation of the country/countries concerned.

Module Content Summary.

In addition to several core topics, each lecturer will contribute specific knowledge from his or her own field of specialisation. Besides grammar, which remains the foundation of all language instruction, the following key areas will be covered:

- Analysis and interpretation of documents (videos, audio materials, news articles, etc.) on various aspects of the civilisation and culture of the countries involved.
- Writing different types of documents that are specific to the engineering profession (correspondence, reports, scientific and technical articles, curriculum vitae).
- Familiarisation with problems specific to "scientific" language (syntactic and lexical).
- Action-oriented approach through role play/group work simulating various professional situations.

English

Department: *Modern Languages*

Year: G2

Category: *Core curriculum*

Semester: *S7-S8*

Duration: *48H (24H in S7 + 24H in S8)*

Organisation: *Series of tutorials (1H30 per week, 2H in S8) totalling 48H in S7 / S8*

Individual work: *Written assignments + research/preparatory work over two semesters*

Assessment: *Continuous assessment (homework and in-class assignments + oral presentations + class participation)*

No. of students: *maximum 18*

Specific rooms: *language rooms with audiovisual equipment + multimedia language lab*

Prerequisites: *validation of English classes in G1 (S5 + S6)*

Lecturer(s): S. Davies -- A. Delame -- V. Dziwniel – J-J Le Yeuc'h – N. Quayle - S. Roskell - External guest speakers.

Objectives.

- Reinforce oral and writing skills acquired in G1, with continued emphasis on communication aspects. The small group size (18 students) lends itself to such an approach.
- Deepen understanding of English-speaking cultures (literature, social problems, politics, geography, etc.) through a variety of materials (videos, radio broadcasts, articles, etc.).
- Continue study of the English-speaking business world with "Market Leader Upper Intermediate", Pearson Longman.
- Advanced preparation for the TOEIC test (Test of English for International Communication), which students are expected to pass in S7 with a minimum target score of 820.

Module Content Summary.

In addition to several core topics, each lecturer will contribute specific knowledge from his or her own field of specialisation. Besides grammar, which remains the foundation of all language instruction, the following key areas will be covered:

- Analysis and interpretation of documents (videos, audio materials, news articles, etc.) on various aspects of the civilisation and culture of the countries involved.
- Writing different types of documents that are specific to the engineering profession (correspondence, reports, scientific and technical articles, curriculum vitae).
- Familiarisation with problems specific to "scientific" language (syntactic and lexical).
- Action-oriented approach through role play/group work simulating various professional situations.
- Case studies of various professional situations.
- Advanced preparation for the TOEIC test (Test of English for International Communication).

Second Language

Department: *Modern Languages*

Year: G2

Category: *Core curriculum*

Semester: *S7-S8*

Duration: *48H (24H in S7 + 24H in S8)*

Organisation: *Series of tutorials (1H30 per week, 2H in S8) totalling 48H in S7 / S8*

Individual work: *Written assignments + research/preparatory work over 4 semesters*

Assessment: *Continuous assessment (homework and in-class assignments + oral presentations + class participation)*

No. of students: *minimum 15 / maximum 18*

Specific rooms: *language rooms with audiovisual equipment + multimedia language lab*

Prerequisites: *validation of Second Language classes in G1 (S5 + S6)*

Lecturer(s): A. Branco – P. Hilleke -- External guest speakers.

Objectives.

Students may choose German, Spanish, Japanese, Chinese or Portuguese as a second language. For non-French students admitted to double-degree programmes, the compulsory second language is French as a Foreign Language. Japanese classes will be held in the evenings at the ENSC de Lille.

Both beginners and non-beginners are accepted. However, there must be a minimum of 15 students per class.

The main objectives are the following:

- Gain and/or further knowledge of basic (syntactic) structures with the help of various materials (videos, radio broadcasts, articles, etc.).
- Familiarisation with the various aspects of the civilisation of the country/countries concerned.

Module Content Summary.

In addition to several core topics, each lecturer will contribute specific knowledge from his or her own field of specialisation. Besides grammar, which remains the foundation of all language instruction, the following key areas will be covered:

- Analysis and interpretation of documents (videos, audio materials, news articles, etc.) on various aspects of the civilisation and culture of the countries involved.
- Writing different types of documents that are specific to the engineering profession (correspondence, reports, scientific and technical articles, curriculum vitae).
- Familiarisation with problems specific to "scientific" language (syntactic and lexical).
- Action-oriented approach through role play/group work simulating various professional situations.

Innovation

Department: *Engineering*

Year: *G1*

Category: *Discipline-based elective module*

Semester: *S6*

Duration: *32 h*

Organisation: *Combination of group lectures and exercises*

Assessment: *Tutorials, project*

Specific rooms: *Video projector*

Prerequisites: *None (usual post-preparatory class standard)*

Lecturer(s): M. Bigand, N. Benkeltoum (coordinator), Dominique Frugier (coordinator).

Objectives:

Innovation is considered to be one of the *key* elements in the competitiveness of modern businesses. This module will provide the theoretical and practical basics of multidisciplinary innovative engineering. It will be centred around the following:

- cognitive science (*forcing, fixation effect, etc.*);
- engineering sciences (TRIZ, C-K theory, etc.);
- economic and management science (*business plan, marketing innovation, etc.*);
- human and social sciences (social innovation, social deadlocks).

Module content summary:

The "Innovation" elective module will cover three aspects of innovation. The first of these has to do with techniques, tools and methods related to creativity and innovation (*lead-user, knowledge brokering, lateral thinking*). The second focuses on valorisation and innovation markets (business models, idea marketing, etc.). The third covers the organisational considerations in innovation (managing and assessing innovative projects, skills, modularity, etc.).

Knowledge:

- creativity and design for innovation;
- valorising and marketing innovation;
- organising for innovation.

Skills:

- exceeding the cognitive and social limits of innovation;
- full process control, from idea to commercial supply;
- application of certain innovative engineering tools, methods and techniques.

Assistance in Project Component

Department: *Engineering*

Year: *G1-G2*

Category: *Project Component*

Semester: *S5, S6, S7 and S8 for projects spanning four semesters*

Duration: *14h*

Organisation: *2h lectures – 8h tutorials – 4h "Project Market"*

Individual work:

Assessment:

Specific rooms:

Prerequisites: *no prerequisites*

Lecturer(s): 80 to 100 members of the teaching, research, administrative and technical staff will assist in the project component.

Objectives.

Students will be provided with scientific, technical and methodological supervision in the project component of their degree. Communication managers and consultants will help students according to the needs of each individual project.

Knowledge:

Introduction to a structured approach for identifying and drawing up projects, and for analysing and assessing the pertinence of objectives. Creating an action plan. Project management and control. Management of procedures for identifying uncertainties inherent in the relationship between a project and its environment.

Skills:

Start with an idea and identify needs, assess impacts and risks, determine and design potential solutions, assess project usefulness and feasibility. Manage the complexity of the approach and the subject. Draw up a qualitative and quantitative specifications sheet. Set technical objectives, evaluate expenses, deadlines, costs, define responsibilities, decision-making and information systems. Apply uncertainty identification techniques. Manage progress, anticipate problems, take dynamic retroactive action in response to events, capitalise for future projects. Produce a working prototype.

Module Content Summary.

Project launch:

- Introduction to project (4h tutorial)
- Brainstorming and group dynamics (2h lecture)
- Brainstorming (2h tutorial)
- Review of brainstorming and project formulation (2h tutorial)
- "Project Market" (4h)

Project assistance:

- Hands-on tutoring of each group (S5, S6, S7 and S8 for projects spanning 4 semesters)
- cf. intranet site: <http://intranet-projets.ec-lille.fr/>

Project Management

Department: *Engineering*

Year: *G1-G2*

Category: *Project Component*

Semester: *S5 – S6 – S7 – (S8)*

Duration: *27h*

Organisation: *10h lectures and 10h tutorials throughout the project*

Individual work:

Assessment:

No. of students: *all first- and second-year students*

Specific rooms:

Prerequisites: *no prerequisites*

Lecturer(s): E. Castelain, R. Vandestienne, M. Bigand, R. Bachelet, D. Le Picart, V. Caigny, L. Prouvost, L. Cayron

Objectives.

Knowledge:

Concept of a project, organisation and environment. Striving for innovation. Project negotiation, definition and establishment. Risk management. Retroactive action in response to current events. Oral communication.

Skills:

Technology watch via the Web. Handle the object (product/service/organisation) through a functional approach. Identify tasks and evaluate expenses. Draw up a work plan (method and familiarisation with a computer tool), a budget. Master presentation techniques and tools. Identify, rank, prevent and monitor risks.

Module Content Summary.

Semester S5:

- Introductory lecture to Project & Safety component (2h)
- Project launch (2h lecture)
- Functional analysis (2h lecture and 2h tutorial)
- Lecture on Intellectual Property (2h)

Semester S6:

- Project Management (2h tutorial)
- Introduction to project management tools (2h tutorial)
- Assessment (2h)
- Tutorial on intellectual property (2h)

Semester S7 (or S7 and S8)

- Follow-up (2h)
- Safety (1h)
- Assessment (2h)
- Press kit (by appointment and project)
- Graphic communication - Poster preparation (2h lecture, 2h tutorial)

Cross-disciplinary elective modules.

Business Modelling and Management

Year: G2

Category: *Cross-disciplinary elective*

Semester: S7

Duration: 96h (25h lectures, 44h tutorials, 25h self-study, 2h talk)

Organisation:

- *Real work with theoretical studies and applications to real case studies*
- *A cross-disciplinary case study will serve as a guiding thread throughout the module*
- *Participation by guest speakers specialising in the fields studied*

Individual work:

Assessment:

- *At each session (MCQ and/or individual work and/or group work)*
- *Written assignment on the central theme (corrected at relevant moments of the module)*
- *30 min oral presentation (groups of 4 students) subject to both individual and group assessment*

No. of students: 32

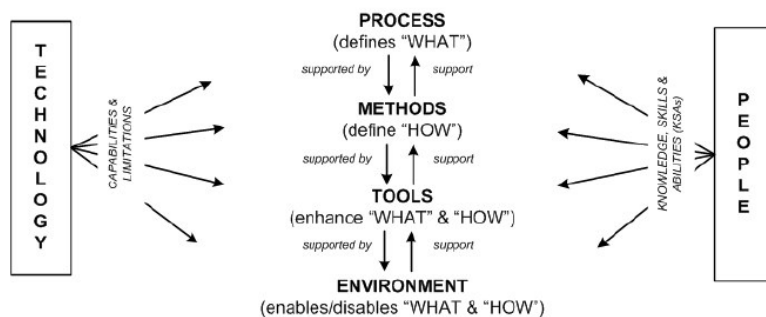
Specific rooms: *Tutorial rooms and computer labs*

Lecturer(s).

Rémi Bachelet, Claire Bélart, Nordine Benkeltoum (co-coordinator) , Michel Bigand, Jean-Pierre Bourey (coordinator), Emmanuel Castelain

Objectives.

- This module is unique to the Ecole in that it teaches engineering students how to incorporate all the technical, economic, human and cultural aspects of complex processes (projects or operations);
- It provides students with tools and methods for carrying out "integration"-type tasks (see figure below), and therefore rapidly exposes them to very important responsibilities in the working world.



More precisely, students will be taught the following:

- The unchanging foundations of business
- How to model a business
- How to improve business performance

Module Content Summary.

- Introduction to modelling
Presentation of module content, concepts of a system and a model, objectives of modelling, typology of models, process approach: methods and tools
- Considering businesses as systems
Business typologies, business functions, various systems: production and logistics, finance, information, steering, HR, extended enterprise, virtual enterprise, two modelling frameworks (Zachman, CEISAR)
- Production and logistic processes

Basics of operations research (Little's law, indicators), identifying, modelling and assessing production flows, incorporating production flows within supply chain management

- Information system

Information systems vs. computer information systems, life cycle of a computer application, modelling with UML, modelling with BPMN, ERP, PLM, PDM, CRM, SCM concepts and key products

- Financial system

Typology of cost calculation and management control methods, ABC approach (Activity-Based Costing)

- Quality management system

Approach to quality, quality standards, change management

- Steering system

Management charts, indicators, audits

Telecommunications Networks

Year: G2

Category: *Cross-disciplinary elective*

Semester: S8

Duration: 96 h

Organisation: *Lectures (18h Telecommunications & 18h Networks), Talks (25h), Mini-Projects (30h), Visits (3h)*

Assessment: *Test on lecture content (1h Telecommunications and 1h Networks), MCQ on IRCICA talks (1h), Mini-projects (1 on Telecommunications and 1 on Networks).*

Specific rooms: *C018/C212 (computer lab for OptiSystem) and B7-01 (computer lab for Networks)*

Prerequisites:

Lecturer(s): O. Bou Matar-Lacaze (contact lecturer), S. El Khattabi, B. Piwakowski, C. Sion, A. Toguyeni

Objectives.

These days, there has been a convergence between telecommunications networks and computer networks. Although these networks carry the same type of data (digital, voice, video, etc.), their service quality standards are very different. The aim of this cross-disciplinary elective is to provide students with an understanding of:

- the current transformations in the telecoms sector, by presenting the foundations of telecoms systems and networks in the OSI model.
- the economic issues in this rapidly expanding sector, by applying engineering concepts (market, standardisation, services) to current and future telecoms networks.

In addition, emphasis will be placed on the services that a business may expect of a telecoms system, e.g. by demonstrating the possibilities offered by the transition from traditional automatic commutation techniques (Pabx) to Internet-based techniques (IPbx).

Module Content Summary.

- Telecommunications Engineering
 - The telecommunications market: current situation & perspectives
 - Project management (Talk: Siemens Telecom)
 - Quality management (Talk: Siemens Telecom)
- Computer networks
 - Standards in computer networks: OSI model, IEEE 802 standards, ATM
 - Wireless computer networks
 - Wi-fi
 - Bluetooth
 - The Internet model
 - IP addressing and routing
 - Data transport via the internet
 - Application
- Network convergence
 - Mobile telephony: all set for UMTS (Talk: Bouygues Telecom)
 - New service quality requirements: ATM model
 - Service quality and the Internet
 - Traffic Engineering and MPLS
 - QoS routing
 - Mobility and the Internet: an Ipv6 solution
 - VoIP and ToiP
 - H323 protocol
 - SLIP protocol
 - Implementation of an IPBx by means of Astérics (Mini-project)

- Telecommunications systems
 - The lower layers of the OSI model (physical layer and principles of modulation)
 - Physics of radio-frequency waves and components
 - Propagation in a terrestrial environment
 - Optoelectronic components (Talk: IRCICA)
 - Guided waves in multimode fibre optics (Talk: IRCICA)
 - Photonic fibres and their applications (Visit: IRCICA photonics platform)
 - Principles of modulation/demodulation
 - Analogue modulation
 - Digital modulation
 - Principles of multiplexing
 - Telecommunications systems
 - Microwave beams
 - Satellite communications
 - Optical fibre systems (Mini-project using the OptiSystem software)
 - RF systems for advanced communications (Talk + visit: IRCICA)
-

High-Speed Transport

Department: *Mechanisms, Structures and Construction*

Year: *G2*

Category: *Cross-disciplinary elective*

Semester: *S8*

Duration: *96 h*

Organisation: *Lectures/tutorials/lab sessions*

Assessment: *Exam*

Specific rooms:

Prerequisites:

Lecturer(s): X. Boidin, J-M. Foucaut, B. François, M. Hecquet, M. Stanislas

Objectives.

- Learn about the various issues related to the development of high-speed rail transport (socio-economic aspects, resources, environmental constraints, performance, safety, etc.)
- Integrate the design complexity of rail transport systems

Module Content Summary.

Introduction to challenging issues and problems in high-speed transport, political openness, competition in the transport industry.

The module will cover three key development areas of rail transport systems:

- Electrical/Civil engineering infrastructure
 - Environmental aspects: communication, signals, soil stabilisation
 - Safety and comfort aspects
- Energy considerations
 - Energy performance
 - Energy management: electric braking, return to catenary, etc.
 - Energy distribution and storage, high-voltage lines, transformers, batteries, consumption of auxiliary components
- Mechanical and aerodynamic considerations
 - Systems aspect, wheel/rail contact problem
 - Mechanical braking: units, technology, thermal considerations, performance issues
 - Train aerodynamics
 - Weight reduction in structures and materials
 - Vibroacoustics, squeal

Bioengineering

Year: G2

Category: *Cross-disciplinary elective*

Semester: S8

Duration: 96 h

Organisation: *Series of seminars + case study + unsupervised work*

Assessment: *Case studies, MCQ, exercises*

Specific rooms: *EC Lille laboratories, partner laboratories, CHRU Lille – equipment: LML facilities, IEMN facilities, laboratories, CHRU facilities*

Prerequisites: *No prerequisites*

In-house lecturer(s): Philippe Pernod, Vladimir Preobrazhensky, Abdelkrim Talbi, Marc Goueygou, Mathias Brieu, Pierre Hottebart

External guest speakers:

CHRU Lille/INSERM: Damien Huglo, Franck Semah, Nacim Betrouni, Patrick Dubois, Maximilien Vermandel, Lucas Mahieux, Crystele Rubod

IEMN/CNRS: Vincent Senez

Objectives.

Train students in an area that lies at the interface between engineering sciences and the biomedical field, with particular emphasis on the current meta-convergence between nanotechnology, ICT and bioengineering. These fields are among the nine European and regional priority areas that have been singled out for research and development. The generalist nature of the Ecole's programmes lends itself to such "interface" modules.

Capitalising on the unique characteristics and strengths of the region's medical, academic and industrial sectors, three particularly promising industries have been selected as the focus of this module: imaging and therapy, bio-micro-nanotechnologies, physics of soft matter/biomaterials/implantable materials. These are areas in which the Ecole and the neighbouring laboratories possess recognised competences and the necessary technical platforms for carrying out demonstrations or catering to students during work placements.

Knowledge:

- Physical concepts used in the selected fields
- Procedures and tools used for designing dedicated systems
- Implemented technologies
- Simulation and post-processing approaches
- Applications in biology and the medical field

Skills:

- Design and dimension the devices studied
- Simulate the devices and systems
- Implementation

Module Content Summary.

- Subject area 1: From imaging to therapy
 - Interactions between waves and living matter: potentialities, permissible radiation limits, therapy (hyperthermia, lithotripsy, etc.)
 - Qualitative, quantitative, functional and interventional imaging (scanners, ultrasound, MRI, nuclear medicine, scintigraphy, PET scan, contrast agent for various techniques, endoscopy, cellular imaging, etc.); explanation of concepts, technological details (sensors, electronics), signal processing techniques, reconstruction and image processing algorithms (3D, quantitative extractions, etc.).
- Subject area 2: Bio-Micro-Nanotechnologies

- Nanoparticles for targeted drug delivery
- BioMEMS, micromanipulators, lab-on-a-chip
- Microfluidics, microcanals, transport, functionalisation
- Subject area 3: Soft Matter and Biomaterials
 - Physics of soft matter
 - Implants, substitute materials, prostheses, etc.
 - Active implantable materials, stents, etc.

From Heat Engines to Hybrid Systems

Year: G2

Category: *Cross-disciplinary elective*

Semester: S8

Duration: 96 h

Organisation: *Lectures + tutorials + lab sessions + project + unsupervised work*

Assessment: *Lab work (for certain topics), project*

Specific rooms: *"Electricity" lab, computer lab ("Matlab Simulink"-"Bond Graph"*

Tutorial room in mechanics: "Study of Mechanisms"

Special facilities at the Lycée du Hainaut Valenciennes: "Engine test bench", "Power test bench", "Engine Disassembly".

Prerequisites: No prerequisites

Lecturer(s): Patrick Dupont (lecturer-in-charge), Geneviève Dauphin-Tanguy, Anne-Lise Cristol, Frédéric Gillon, Philippe Quaegebeur, Bouaziz Tolba.

External guest speakers: Lycée du Hainaut Valenciennes.

Objectives.

Context:

Many hybrid vehicles are now available on the automotive market. This development has largely been prompted by the economic and environmental situation. The construction of such vehicles requires wide-ranging expertise and knowledge in areas such as combustion, energy, heat engines, transmission systems, electric motors, batteries and materials for automobiles. The objective of this module is to provide students with knowledge in all these areas. Acquired knowledge will be used to develop a "Bond Graph" model of a hybrid vehicle.

Knowledge:

The cross-disciplinary elective *From Heat Engines to Hybrid Systems* has been designed to teach students about the latest technical developments in the automobile industry, especially hybrid systems.

Module Content Summary.

- Combustion, energy balance, pollution from heat engines
- Evolution of heat engines,
- Study of the transmission chain,
- Electric motors and batteries,
- "Bond graph" approach,
- Materials for automobiles.

Lesson plan:

- An introductory talk given by an industrial partner from the automobile industry on the motorisation challenges in tomorrow's vehicles, as well as systems approaches.
- Practical teaching has been scheduled for each topic.
- At the end of the module, a project will be presented in the presence of an industrial partner.

iNnovative ExperiMEnts for engineering ScienceS (NEMESIS)

Department: *EEA*

Category: *Cross-disciplinary elective*

Semester: **S8**

Duration: *96 h*

Lecturer-in-charge: *Abdelkrim Talbi*

Organisation: **40 h: Lectures, seminars, visits to research centre / 56h case studies + unsupervised work**

Assessment: *Case studies*

Specific rooms: *EC Lille laboratories and partner laboratories – equipment: LML facilities, IEMN facilities, L2EP facilities, EC Lille workshops, laboratories*

Prerequisites: *No prerequisites*

Lecturer(s): Michel Hecquet, Jean-Claude Tricot, Emmanuel Delmotte, Jean-Marc Foucaut, Philippe Quaegebeur, Ahmed Elbartali, Emmanuel Duflos, Sebastien Coudert, Franck Kerhervé, Michel Stanislas, Abdelkrim Talbi.

External participants: CNRS, ONERA, USTL.

Objectives:

Experimental methods used in all areas of **engineering science** are developing at an extremely fast pace thanks to technological **innovations** in instrumentation and computing.

All the **laboratories** at the Ecole Centrale are **leaders in the latest experimental techniques** and the members of the various **research teams** wish to share their knowledge and expertise with students.

Innovation in experimental methods is related to the development of new and complex systems that incorporate miniaturisation technologies and an increasing number of intelligent functions. The in situ integration of multiple functions in products, production lines and machinery is now of major concern in many **industrial sectors**, e.g. the automotive, aerospace, telecommunications, computer, medical and research industries, as well as the production of state-of-the-art scientific equipment.

The **NEMESIS** cross-disciplinary elective aims to provide students with scientific and technological grounding in the latest innovations in instrumentation, experimental techniques and data analysis in multi-technology fields. Such knowledge and skills are absolutely essential for R&D in academic and industrial sectors alike.

Teaching approach

The following methods will be used with equal emphasis and in a complementary manner:

- **Interactive lectures/presentations:** Provide students with the necessary scientific and technological knowledge for an overall understanding of multidisciplinary systems that incorporate innovative functions and materials: micro/nanotechnologies, matter exploration (solid and fluid) by imaging and instrumental analysis (optical microscopy, laser acoustics, near field, infrared and electronics), measurement and multi-instrumentation (new acquisition and data analysis technologies).
- **Case studies:** Address certain problems in case studies where systems engineering approaches are used.
- **Visit to academic and industrial research centres:** hear the experience of those who manage state-of-the-art equipment in various laboratories or research centres in the region.

Technical resources and facilities:

- Vibration analysis is now a standard process that is carried out on components and systems in motorised vehicles, aerospace vehicles or MEMS.
Non-contact modal analysis: laser vibrometer interferometer for measuring vibrations in microstructures through a differential method, which makes it possible to determine velocity or

displacement with a resolution of a few nanometres. Contact modal analysis: accelerometers, strain gauges.

- Scanning near-field microscopy or scanning probe microscopy for characterising physical behaviour (electrical, mechanical, chemical, magnetic, etc.) of novel materials or components at the nanometric scale.
- Optical diagnostic systems at the micro- and macroscale with high spatial and temporal resolution. In fluid mechanics, these techniques are used to obtain quantitative images of many flow parameters such as density, temperature, concentrations and velocity. In the field of materials, surface imaging enables the user to obtain data on shape, strains and stresses without the need for complicated calibration.

Examples: Particle image velocimetry (PIV), field approach, Raman scattering, Rayleigh scattering and laser-induced fluorescence (LIF), infrared thermographic imaging, reconstruction and morphological analysis in imaging.

Energy Strategy and Alternative Electricity Generation

Year: G2

Category: *Cross-disciplinary elective*

Semester: S8

Duration: 96h

Organisation: *Lectures/tutorials/lab sessions/case study (unsupervised work)*

Assessment: *Case study/lab work/MCQ*

Specific rooms: *Computer rooms (simulation) and laboratory*

Prerequisites: *Core curriculum*

Lecturer(s).

Lecturers-in-charge: B. François, X. Guillaud

Participating lecturers: P. Dupont, P. Fongarland, J.M. Foucaut, V. Le Courtois, S. Paul, B. François, X. Guillaud.

Objectives.

At the end of this cross-disciplinary elective, students will be capable of measuring the environmental impact of the energy strategy chosen for a given mode of electricity generation. They will know how to analyse the various existing and emerging alternatives for energy conversion.

Module Content Summary.

To achieve these objectives, the entire electricity generation chain will be presented. The different stages will be studied in detail: primary energy resources, basic chemical reactions, the different types of turbines that convert primary energy into mechanical power and, at the end of the chain, synchronous machines for electricity generation. The specific problems of power grids will serve to demonstrate the importance of carrying out dynamic modelling of the various elements within this complex conversion chain.

- General introduction

Power grids: a fast-changing situation (liberalisation of the electricity market, large-scale introduction of renewable energy, evolution of modes of consumption, etc.).

Distribution of primary energy resources in the world and geopolitical issues.

- Primary energy resources

Analysis of the different types of primary energy resources for electricity generation. Environmental impacts of the various forms of electricity generation.

- Linking production sources

Behaviour of synchronous machines within a power grid.

Influence of source dynamics on the dynamic behaviour of grids.

New form of electricity generation: how variable-speed technology can be used to optimise energy conversion, especially in the case of renewable energies.

Towards Sustainable Materials

Year: G2

Category: *Cross-disciplinary elective*

Semester: S8

Duration: 96h

Organisation:

Assessment:

Specific rooms:

Prerequisites: none

Lecturer(s)-in-charge: Jean-Yves Dauphin.

Objectives.

- Acquire an understanding of multiphysical loads and couplings to which materials in real structures are subjected. These can range from small objects to industrial structures and great feats of civil engineering.
- Better understand how materials respond to such loads and couplings in terms of behaviour, transformations and ageing.
- Learn how to define and select materials to better suit the intended function.
- Know how to exploit their behaviour and evolution for sustainable use: improve reliability, increase lifespan, respect the environment and recycle.

Knowledge:

Basic concepts in physics, materials science and mechanics taught in the core curriculum.

Module Content Summary.

- Specifications.

This module relies on the competences and experimental resources of the Ecole's research teams specialising in materials processing and the study of material behaviour. The relevance of this module will be highlighted by demonstrating the links with current concerns in industry and society.

- Module Content Summary.

The module will begin with a description of the main categories that form the bulk of today's industrial materials, both from a technical and economic point of view. Some other fundamental topics that are only touched on in the core curriculum will also be examined, e.g.:

- Failure of materials.
- Demonstration of the physical, mechanical and chemical behaviours of materials and their influence on structural design and material selection.
- Considerations of materials with "property gradients" (composites, coatings, surface treatments).
- Phase changes and their applications in "intelligent" materials.

In addition to its academic aspect, this module will also focus on experiments and practical demonstrations in the form of lab sessions. Industrial guest speakers will be invited to give talks on current developments in materials that promise to improve product durability.

A large part of the module (both in terms of subject area covered and time spent) will involve cross-disciplinary case studies in which multiphysical couplings are an important feature.

Architectural Design and Sustainable Construction

Year: G2

Category: *Cross-disciplinary elective*

Semester: 3

Duration: 96h

Organisation: *Weekly full-day session throughout the semester*

Assessment: *Continuous assessment (mid-module assignments) and final oral presentation*

Specific rooms: *Design studio*

Prerequisites: none

Lecturer(s): Ph. Deshayes, A. Leblanc, S. Brisset, Z. Lafahj, H. Wilquin, P. Bernard, F. Poiteaux

Objectives.

Knowledge:

Architectural design, construction and engineering (including ecodesign, HQE approach, home automation and energy performance of buildings), architecture, urbanisation and sustainable development (including ecodistricts and sustainable districts).

Skills:

Architecture project (integrated project exercises), visual expression and graphical representation in design (sketching phase and advanced phase).

Module Content Summary.

The first objective of this module is to teach students the fundamental and updated concepts in *architectural design* and *structural engineering* in the face of current challenges in sustainable development. The use of design tools and approaches is taught as part of building engineering within a multi-actor context (architects, design departments, consulting firms, building companies, material suppliers and distributors, clients, public actors, social actors, etc.).

This module also goes beyond architectural design and construction, as it invites students to get to know various aspects of industrial engineering: product and systems design, interoperability between different actors in a project, client's place and role, etc.

The second objective of this module is to prepare students for the "engineer-architect" double-degree programme that has been established in the TIME network with the Faculté Polytechnique de Mons (Belgium) and the Politecnico di Milano (Italy). European recognition of the title of architect-engineer (and the freedom to practise) requires that four years of study be specifically related to architecture.

Therefore, this module is **COMPULSORY** for students who wish to pursue the double-degree programme. It should be taken in conjunction with advanced modules in physical sciences for engineers that are related to the field of construction, and possibly some other cross-disciplinary modules.

A Responsible Approach: Ecodesign

Year: G2

Category: *Cross-disciplinary elective*

Semester: S8

Duration: 96h

Organisation: *Lectures, tutorials, lab sessions, unsupervised work.*

Assessment: *Mid-module exam + mini-project + case study*

Specific rooms: *3 computer rooms + video rooms*

Prerequisites: *Motivation and common sense*

Lecturer(s): F. Aldebert; D. Balloy; S. Brisset; A. Leblanc; D. Le Picart; C. Niclaeys; S. Paul; C. Sion; J.C. Tissier; A. Wignacourt.

Objectives.

Raise students' awareness of the need for a more well-rounded approach to design in order to incorporate a more highly developed thinking phase. Develop responsible behaviour for taking into account, using the appropriate means, the environmental, social and economic parameters that must be handled.

Knowledge:

Knowledge of ecodesign methods and tools; implementation of dedicated resources in applications.

Skills:

Apply a structured approach to a limited subject matter chosen among the four industrial sectors featured in this module: Mechanics; Electricity - Electronics; Process Engineering and Civil Engineering

Module Content Summary.

Three key phases:

- "Basic" knowledge
 - Essential knowledge: regulations and incentives
 - "Product" resources
 - Creativity techniques
 - Value engineering
 - Life-cycle analysis (LCA) and tools
 - Carbon footprint and main software tools
- Talks and visits associated with real ecodesign achievements; contact with production sector.
- Applications (individual and group)
 - Detailed study of an ecodesign topic
 - Case study (in groups of four at the most) on a topic proposed by each application sector.

Ambient Intelligence

Year: G2

Category: *Cross-disciplinary elective*

Semester: S7

Duration: 96 h

Organisation: *Lectures, lab sessions, visits*

Individual work: 16 h

Assessment: *Mini-projects, group work*

No. of students: *maximum 32 students*

Room/Materials: Computer lab for lab work

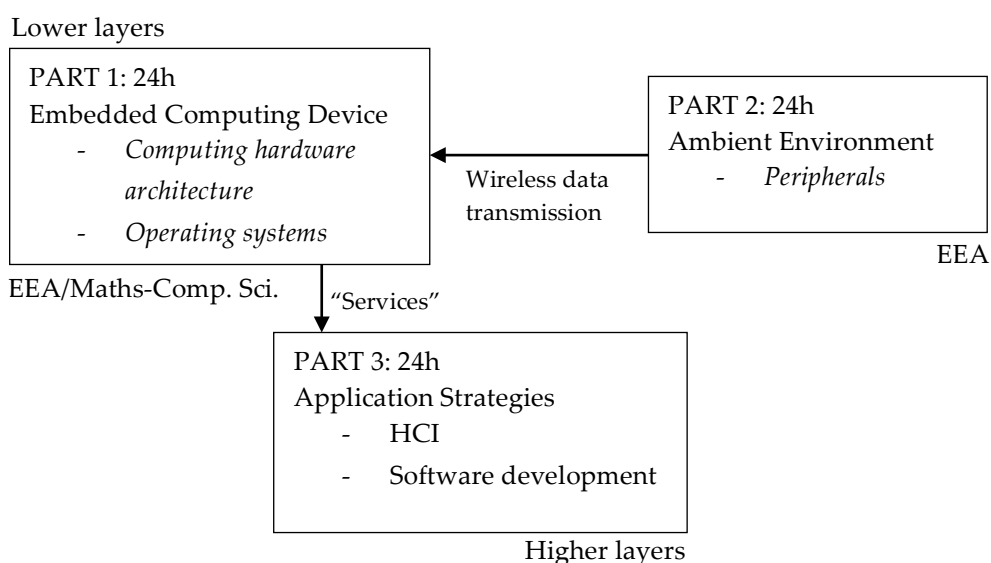
Lecturer(s): Thomas Bourdeaud'huy, Emmanuel Delmotte, Jean-Pierre Richard, Alexandre Kruszewski, Samir El Khattabi, Armand Toguyeni, Emmanuel Duflos, Abdelkrim Talbi, Khaled Mesghouni

Objectives.

The term "ambient intelligence" is used to refer to environments that combine hardware, software and embedded systems contained in objects or people, which, thanks to communication and self-organising devices, enable the provision of new services specially adapted to on-the-go users in this information society. In addition, most of these new systems deal with the acquisition, handling and generation of massive amounts of information, knowledge, images and multimedia data - quantities of information that are barely conceivable by the human mind.

The objective of this elective is to present the technologies and methodologies for designing such devices. After an introductory lecture, lessons will be split into 3 parts. One topic will be covered each week.

Assessment will be based on group work, in which students will have to compile a dictionary of ambient intelligence, pool lecture notes, carry out mini-projects in twos, and demonstrate a prototype at the end of the module.



Module Content Summary.

Week 1: Introduction to ambient intelligence; revision of the physics of waves

Basics of wave physics: propagation in telecommunications, 2h, Ali Soltani

Basics of data transmission technologies: signals, encoding, modulation, 2h Emmanuel Delmotte

Energy problems, 4h, Christophe Letien

Week 2: Embedded computing device

Computer architecture, 4h Bruno François

Presentation of FPGA, 2h Emmanuel Delmotte

VHDL lab session, 4h Khaled Mesghouni, Abdelkrim Talbi

Week 3: Computer networks

General concepts of computer networks, 4h, Armand Toguyeni

Wireless networks: Wi-fi, Zigbee, Bluetooth, 4h Armand Toguyeni

Influence of networks on control loops, 2h, Jean-Pierre Richard

Quality of network services, 2h, Armand Toguyeni

Week 4: Home automation

Radio protocols, Zigbee industrial approaches, 2h, Philippe Bretagne (Cléode company)

Introduction to home automation protocols: PLC, EIB, 3h, Daniel Spitz, HEstia company

Week 4: RFID at Centre for Innovation in Non-Contact Technologies 12h

Week 5: Sensor networks

Haptic interfaces and network control, 2h, Alexandre Kruszewski

Communication devices, 3h, Laurent Clavier

Data fusion, 2h, Emmanuel Duflos

Week 6: HCI at Valenciennes

Automobiles and ambient intelligence, non-contact HCI

8h: Thierry Delot, Frédéric VanderHaegen, Christophe Kolski

Week 7: Operating systems

Fundamental principles of OS's, 4h, Samir El Khattabi

Android lab session, 8h, Thomas Bourdeaud'huy

Week 8: Artificial intelligence and collective intelligence

Multi-agent systems, 12h, Philippe Mathieu, LIFL

Week 9: Mini-project oral presentations