CENTRALE NANTES

# INGÉNIEUR, SPÉCIALITÉ MÉCANIQUE

2021-2022

Year 2

PROGRAMME SUPERVISOR

Pascal COSSON

# Year 2

| Course unit | ECTS Credits | Course type | Course code | Title |
|---|---|---|---|---|
| UE200 | 13 | | | |
| | | Core course | MECA2_ENTRE | Business Skills |
| UE201 | 3 | | | |
| | | Core course | MECA2_SSAT | Social Sciences Applied to the Workplace |
| | | Core course | MECA2_SSATFC | Social Sciences Applied to the Workplace (training sessions) |
| UE202 | 2 | | | |
| | | Core course | MECA2_ANGL | English |
| | | Core course | MECA2_ANPRA | Analysis of profesionnal practises |
| | | Core course | MECA2_ESE | Social challenges for the companies |
| | | Core course | MECA2_PSI | International Experience Project |
| UE203 | 9 | | | |
| | | Core course | MECA2_GI1 | Industrial Engineering - Part I |
| | | Core course | MECA2_GI2 | Industrial Engineering - Part II |
| UE204 | 5 | | | |
| | | Core course | MECA2_MATHS | Mathematics |
| UE205 | 4 | | | |
| | | Core course | MECA2_MATER | Materials |
| UE206 | 4 | | | |
| | | Core course | MECA2_DSOLI | Rigid Multibody Dynamics |
| UE207 | 5 | | | |
| | | Core course | MECA2_RDM | Continuum mechanics and Strength of materials |
| UE208 | 4 | | | |
| | | Core course | MECA2_INFO | Computer science - Database |
| UE209 | 4 | | | |
| | | Core course | MECA2_THERM | Thermic et Thermodynamics |
| UE210 | 5 | | | |
| | | Core course | MECA2_CAPT | Sensors |

# Business Skills [MECA2_ENTRE]

*LEAD PROFESSOR(S): Marie GOUGEON / Pascal COSSON*

## Objectives

This second year business skills course, following on from the first year, is not an academic course. Rather it addresses the learner's experience in the host company during his/her apprenticeship and the analysis he/she makes of this experience. It focuses on the learner's development during his/her periods in the company, on the skills acquired and on his/her ability to project him/herself as an engineer. The first year course was more geared more towards discovering the company, joining the world of work, and the first assignments. The second year should enable the student to take on more responsibility. It is also the year in which the End of Study Project is set up, which will enable him or her, in the third year, to prove that he or she is capable of fulfilling all aspects of an engineering post: organisational, scientific and technical, human and economic.

The course is assessed using the following elements:

- completion of ``the Carnet de Suivi Electronique", an electronic logbook;
- the evaluation completed by the industrial tutor at the end of each semester,
- presentation of the End of Studies project, a document that the apprentice must write in his or her second year.

## Course contents

As in the first year, the industrial tutor completes the skills matrix at the end of each semester and focuses on the skills acquired in the company during the second year. The skills targeted are those of the RNCP "formation Ingénieur Spécialité Mécanique". Each competency is assessed through activities for which four levels are defined:

- level 0: does not know how to do or not applicable;
- Level 1: knows how to do under supervision;
- Level 2: knows how to do independently;
- Level 3: knows how to do and can train others.

The End of Study Project, which takes place within the company during the third year of training, is an opportunity for the apprentice to demonstrate that he or she is capable of fulfilling all four aspects of an engineering post (as listed above): organizational, scientific and technical, human and economic. This project is put in place in the second year. The apprentice has to write a summary presentation of his/her End of Study Project. This presentation will be reviewed by the Commission, which will verify the document's compliance with requirements. This presentation, which must be comprehensible to all, is also an exercise through which the apprentice's ability to step back, to respect a set of specifications and to plan for the future is assessed. This presentation (of around 10 pages) must contain the following elements:

- presentation of the company (about one page);
- reasons for the project (about one page);
- detailed presentation of the project (about one page);
- detailed presentation of the apprentice's positioning (about one page);
- presentation of the planned scientific development (about one page)
- presentation of the economic situation (about one page);
- deadlines and schedules.

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 6 hrs | 0 hrs | 0 hrs | 0 hrs | 0 hrs |

# Social Sciences Applied to the Workplace [MECA2_SSAT]

*LEAD PROFESSOR(S): Fabien THOMAS / Pascal COSSON*

## Objectives

The objectives of this module are as follows:
▪ acquire a rational approach to questioning in the context of a human work-related practice;
▪ acquire a data collection methodology adapted to this questioning;
▪ learn about human work-related practice;
▪ bring together "practices" and "theories" based on the professional experience of degree-apprenticeship engineering students (in conjunction with practice analysis sessions);
▪ transform this knowledge into professional know-how.

To this end, the module includes:
▪ presentations on various areas of human work;
▪ research conducted over three years, based on a work situation in the apprentice's host company (formalised via a dissertation);
▪ individual follow-up with a course teacher (questioning, structuring the research, and correction of the deliverables and dissertation).

The teaching provided is based on an alternating educational approach, specific to apprenticeship. This requires degree-apprentice engineering students to focus on real-life situations in their company. However, they should neither endorse nor denigrate the latter, nor express their personal opinions or feelings. Discipline, perspective, research work, and personal culture in various areas such as economics, social and legal matters are required.

## Course contents

Field survey
Writing practice
Evaluating work
Team work
Progress reviews and presentations
Post-presentation workshop
Legal and social environment

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 49 hrs | 0 hrs | 0 hrs | 0 hrs | 0 hrs |

# Social Sciences Applied to the Workplace (training sessions) [MECA2_SSATFC]

*LEAD PROFESSOR(S): Fabien THOMAS*

## Objectives

## Course contents

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 21 hrs | 0 hrs | 0 hrs | 0 hrs | 0 hrs |

# English [MECA2_ANGL]

*LEAD PROFESSOR(S): James RATCLIFF*

## Objectives

▪ prepare students for TOEIC test (grammar, vocabulary, listening, reading). Required TOEIC score: 785

If students have been unable to carry out foreign internship at end of 1st year due to covid restrictions:
▪ prepare students to apply for internship in English-speaking country
▪ prepare students for life in a company in English-speaking country
▪ prepare students for living abroad, integrating with English-speakers

## Course contents

TheTraining program/syllabus (to adapt according to whether students have carried out foreign internship at the end of first year):

Communicative approach:

▪ CVs in English
▪ Cover Letters in English
▪ Video CV scripts
▪ Describing companies and responsibilities within companies
▪ Job interview practice
▪ Telephoning for job interviews. Leaving a message
▪ Telephoning: arranging a meeting.
▪ Describing processes
▪ Numbers, figures, prices, measurements, alphabet, graphs, charts etc.
▪ Question forms
▪ Communication activities in various contexts - professional, social, current affairs
▪ Grammar review according to individual needs
▪ Vocabulary for TOEIC
▪ Professional emails
▪ Professional role-plays
▪ Presentations skills & practice
▪ Case studies
▪ Meetings language
▪ Social English
▪ Cultural Differences – working in UK, US, Australia etc

Regular Mock T.O.E.I.C practice tests

## Course material

Barron's TOEIC Test 6th Edition
English Grammar in Use with answers - Raymond Murphy
200% TOEIC 2021 - Ellipses
L'intégrale TOEIC - Nathan
Les Guides Officiels du test TOEIC Grammaire Vocabulaire du test TOEIC - Hachette

## Assessment

Individual assessment: EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| English | - | 0 hrs | 24 hrs | 0 hrs | 0 hrs | 4 hrs |

# Analysis of profesionnal practises [MECA2_ANPRA]

*LEAD PROFESSOR(S): Marie GOUGEON / Pascal COSSON*

## Objectives

To enable apprentices to move from a “student” position to a “professional” position through:

A reflection on their learning methods and methodologies,

Identification of efficient practices,

An exchange between peers,

A link between the two training places: the school and the host company.

## Course contents

Examples of topics include:

Integration of the apprentice into a company,

The use of information and communication tools,

Training at the school,

Peer-to-peer training,

Appropriation of the training system

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 6 hrs | 0 hrs | 0 hrs | 0 hrs | 0 hrs |

# Social challenges for the companies [MECA2_ESE]

*LEAD PROFESSOR(S): Pascal COSSON / Stéphane GUYARD*

## Objectives

The "Societal challenges and Business" course aims to acquire skills in terms of a scientific approach to analysing the functioning and evolution of companies (questioning, data collection and analysis). The skills developed are fully in line with the Common Basis for Apprenticeship Training (CBAT) led by ITII.

This course concerns the first two years of Mechanical Engineer Specialty training. It is based on a joint study (in groups of 4 or 5 apprentices) on topics concerning the relationship between contemporary societal challenges and the functioning and evolution of companies.

The surveys are carried out mainly within the framework of companies in the mechanical engineering sector. The pooling of the contexts and experiences of the apprentices must allow the sharing, the confrontation and a certain increase in generality of the results.

The pedagogy is organized around sessions of transmission of theoretical knowledge and methodologies and sessions of support of apprentices by teachers. In order to ensure the continuity and coherence of the support, the same teacher follows apprentices over the two years. This last point must allow a better readability for them and promote a lasting link and a continuity of their work over the two years.

## Course contents

Organization year Y2:
- conducting the empirical survey (scientific interviews, questionnaires, observations, literature review);
- analysis of the data collected;
- presentation of the survey and the results during a defense at the end of the second year.

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 20 hrs | 0 hrs | 0 hrs | 0 hrs | 0 hrs |

# International Experience Project [MECA2_PSI]

*LEAD PROFESSOR(S): Alan BALL / Pascal COSSON*

## Objectives

## Course contents

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 8 hrs | 8 hrs | 0 hrs | 0 hrs | 0 hrs |

# Industrial Engineering - Part I [MECA2_GI1]

*LEAD PROFESSOR(S): Catherine DA CUNHA*

## Objectives

- Know how to identify risks in the company
- Understand the role of quality
- Know the tools of innovation
- Know how to model a value chain
- Know lean tools
- Know how to analyze financial data

## Course contents

I Operational management
- Risks and prevention
- Lean management

II The customer
- Need and innovation

Knowledge:
- Innovation
- Environmental issues
- Circular economy

Skills:
- Being open and listening
- Understanding complexity
- Undertake and imagine

III Transversal - Flows
- Supply chain management
- Lean manufacturing

Value Stream Mapping
Knowledge:
-Knowledge of the methodology and formalism
Skills:
-Ability to implement the method
-Ability to identify the added value

IV Economics
Knowledge:
-Difference between profit and cash flow
-The 3 levels of profit and loss
Skills:
-Ability to understand cash flow
-Ability to extract key information from a group report

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 0.25)
EVI 2 (coefficient 0.25)
EVI 3 (coefficient 0.25)
EVI 4 (coefficient 0.25)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 60 hrs | 0 hrs | 0 hrs | 0 hrs | 0 hrs |

# Industrial Engineering - Part II [MECA2_GI2]

*LEAD PROFESSOR(S): Pascal COSSON*

## Objectives

## Course contents

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 0.5)
EVI 2 (coefficient 0.5)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 80 hrs | 0 hrs | 0 hrs | 0 hrs | 0 hrs |

# Mathematics [MECA2_MATHS]

*LEAD PROFESSOR(S): Jean-Sebastien LE BRIZAUT*

## Objectives

evelop the basic notions in analysis and linear algebra in order to acquire a method of reasoning and calculation techniques allowing to approach the teaching of the terminal cycle

## Course contents

Analysis (integer series, Fourier series, Laplace transformation)
Probability and Statistics I (definitions, random variables, Statistics for description)
Probability and Statistics II (random vectors, calculation of statistical laws, Estimation of parameters, confidence intervals, statistical tests)

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 0.3)
EVI 2 (coefficient 0.3)
EVI 3 (coefficient 0.4)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 52 hrs | 10 hrs | 0 hrs | 0 hrs | 6 hrs |

# Materials [MECA2_MATER]

*LEAD PROFESSOR(S): Bertrand HUNEAU / Christian BURTIN*

## Objectives

Objectives:

Complement useful knowledge and concepts in materials science.
These include creep, fatigue, heat treatments, corrosion and tribology.

there is a project about material science. An oral presentation will be done.

Finally, a synthesis of teaching in materials science is carried out by means of a micro memory which is an exhaustive study of a «materials» application within the learner's company. This work makes it possible to put into practice the knowledge, concepts and tools assimilated during teaching. a report and an oral presentation will be done in third year.

## Course contents

1. heat treatments

2) fatigue

3) creep

4) corrosion

5) tribology

2 written assignments + oral defence.

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 1)
EVI 2 (coefficient 1)
EVI 3 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 36 hrs | 0 hrs | 4 hrs | 0 hrs | 0 hrs |

# Rigid Multibody Dynamics [MECA2_DSOLI]

*LEAD PROFESSOR(S): Pascal COSSON*

## Objectives

The objective of this second year course is to study the movement of systems made up of non-deformable solids subjected to an external loading. It follows on from the first year course of the same name, which dealt with modelling these systems and obtaining the equations governing their movements. The course is divided into two parts:

The first part focuses on solving the equations of motion according to the small motion hypothesis. Classically, under this hypothesis, the equations of motion are linearized and an exact solution can be obtained. This approach makes it possible to describe the vibrations of linear systems. In this part of the course, the eigenvalue problem that appears in Solid State Dynamics, the concepts of modes and the modal decomposition of the response of a material system under the small motion hypothesis are presented.

The second part of this course covers solving equations of motion in the general case. Actually, the complexity of these equations means that they can hardly ever be solved exactly. In order to know the time evolution of the considered systems, it is therefore often necessary to set up time integration schemes in order to obtain a numerical solution.
The basic concepts of time integration are developed for a linear and unconstrained system of differential equations. Four schemes are introduced: Euler's explicit and implicit methods, RUNGE KUTTA method (which is a well-known first order time integrator) and NEWMARK scheme (an efficient and commonly used second order time method). Explicit and implicit schemes, consistency, stability and precision are discussed. For a non-linear system of differential equations, when the formulation is implicit, it becomes necessary to set up an iterative resolution at each time step. The implementation of the solving algorithm is detailed, based on rewriting the system of differential equations in incremental form. This part of the course on solving equations of motion outside the framework of the small motions hypothesis ends with an introduction to difficulties that arise when differential equations form a constrained differential system.

## Course contents

1. Vibrations of linear systems
1.1. Vibrations of single degree of freedom systems
1.2. Vibrations of multi-degree of freedom systems

2. Time integration of motion equations
2.1. Time integration of linear systems
2.1.1. First order time schemes
2.1.2. Second order time schemes
2.2. Time integration of non-linear systems
2.3. Time integration of constrained systems

## Course material

M. GERADIN and D. RIXEN. Mechanical Vibrations – Theory and application to structural dynamics. LAVOISIER, 2015, third edition.

S.S. RAO. Mechanical Vibrations. PEARSON PRENTICE HALL, 2004, fourth edition.

## Assessment

Individual assessment: EVI 1 (coefficient 0.5)
EVI 2 (coefficient 0.5)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 10 hrs | 12 hrs | 24 hrs | 0 hrs | 2 hrs |

# Continuum mechanics and Strength of materials [MECA2_RDM]

*LEAD PROFESSOR(S): Laurent GORNET*

## Objectives

Objectives:

At the end of the course, the future engineer must be able to:
Dimensioning simple structures (long beam theory) under the effect of elementary stresses: normal force, bending, torsion

## Course contents

The programme covers stresses, deformations and the calculation of beams. The Virtual Works method is used to present the Finite Elements method for material strength. The practical work is simulated with the EF ABAQUS code.

The programme is divided into sequences, defined as follows:

7 sequences for the course part and tutorials, 2 sequences of practical work (tests and EF simulations).

Course Program and Tutorials:

Part 1:
- Introduction, stresses, deformations. Stress/deformation relationships, MMC directed work.
- Studies of straight beams (tensile/compression-bending, torsional),
- Torsion center (open section bending torsion coupling)

art 2:
- Principle of Virtual Works
- Introduction to the finite element method for beams (analytical exercises and simulations on ABAQUS)

Programme of practical work
- Comparison of bending profiles - deflected bending, - strain gauges, curved beam, beam buckling, cylindrical pressure vessel.

Knowledge Checks ( Two Written Assignments + TP + Digital TP ABAQUS)

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 0.3)
EVI 2 (coefficient 0.3)
EVI 3 (coefficient 0.4)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 32 hrs | 16 hrs | 8 hrs | 0 hrs | 4 hrs |

# Computer science - Database [MECA2_INFO]

*LEAD PROFESSOR(S): Raphaël CHENOUARD*

## Objectives

Understand how  an information system works
Modeling and implementing a database.

## Course contents

- Introduction to information systems
- Conceptual modeling of a database
- Relational databases
- SQL language

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 8 hrs | 20 hrs | 12 hrs | 0 hrs | 0 hrs |

# Thermic et Thermodynamics [MECA2_THERM]

*LEAD PROFESSOR(S): Bruno COURANT / Pascal COSSON*

## Objectives

Objectives:

At the end of the course the future engineer must be able to:

define a specification for a simple thermal installation,

to understand technical solutions and to establish a technical dialogue with external stakeholders,

to design and implement simple installations in the field of heat exchange, steam production and refrigerating machines.

## Course contents

Program of the module:

Heat, work, units, sign convention,

first principle,

state change equilibrium, latent heat, specific heat.

State equation of a fluid, perfect gas, real gas,

reversible transformations,

isothermal and adiabatic transformations.

Adiabatic and isothermal compressors,

second principle, entropy,

monothermous, dithermous cycles,

principle of Carnot.

Change of state of a fluid, Clapeyron diagram, Mollier diagram,

application: description of the cycle of thermal machines, calculation of yields.

Study of the refrigerating machine and heat pump, wet air diagram, application to air conditioning, drying.

Thermal exchanges,

conduction, natural and forced convection, radiation.

Calculation of thermal resistances,

insulation of walls and pipes,

heat balance, heat exchanger balance.

Knowledge Check:

1 written duty.

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 0.5)
EVI 2 (coefficient 0.5)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 16 hrs | 6 hrs | 16 hrs | 0 hrs | 2 hrs |

# Sensors [MECA2_CAPT]

*LEAD PROFESSOR(S): François AUGER / Pascal COSSON*

## Objectives

This course aims to prepare the future mechanical engineer to understand, implement, use, interpret and improve the tools and techniques used in measurement and control.
The choice of control technique and its development will be encourages by integrating notions of cost, reliability, compatibility with quality requirements and the capacity of those who will implement these techniques. For certain techniques, emphasis will be placed on the safety conditions related to their implementation.
The engineer must not only be able to perform the control or measurement, but above all to interpret the results, to choose the place and mode of physically measured information.

The practical work will consist of:

- practical work specific to the discipline;
- applications to all practical measurement work in other scientific and technical disciplines.

## Course contents

Physical principle of mechanical, pneumatic, electrical, opto-electric sensors and their handling.

1. Metrological characteristics of sensors
- accuracy,
- sensitivity,
- operating ranges,
- deviations and external constraints,
- bandwidth,
- response time.

2. Measurement processing
- amplification,
- data transmission,
- analog processing (filtering etc.)

3. Signal Processing
- sampling,
- time descriptors,
- frequency descriptors,
- spectral analysis.

4. Application Elements
- dimensional metrology,
- process control sensors,
- data entry and processing software,
- choice of sensor.

5. Assessment
Two written tests and two practical exercises.

## Course material

## Assessment

Individual assessment: EVI 1 (coefficient 0.5)
EVI 2 (coefficient 0.5)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| French | - | 20 hrs | 8 hrs | 32 hrs | 0 hrs | 2 hrs |