CENTRALE NANTES

ENGINEERING IN THE FIELD OF EMBEDDED SYSTEMS

2021-2022

Year 2

PROGRAMME SUPERVISOR

Olivier Henri ROUX

Year 2

Course unit	ECTS Credits	Course type	Course code	Title
UE200	20			
		Core course	SEC2_ADP	Analysis of Professional Practices
		Core course	SEC2_ENT	Business Skills
		Core course	SEC2_PFE	Preparation of final project
UE201	5			
		Core course	SEC2_ESE	Social challenges for the companies
		Core course	SEC2_SSAT	Social Sciences Applied to the Workplace
UE202	2			
		Core course	SEC2_DPI	Law and Intellectual Property
		Core course	SEC2_EE	Business Economics
UE203	15			
		Core course	SEC2_LE	Embedded Linux
		Core course	SEC2_PS	Smartphone programming
		Core course	SEC2_PTR	Real-time programming
		Core course	SEC2_RTOS	Construction of an RTOS
		Core course	SEC2_SI	Computer security
		Core course	SEC2_SINT	Interconnected Systems
UE204	14			
		Core course	SEC2_ALC	Actuators and Control Laws
		Core course	SEC2_CE	Electronic Circuit
		Core course	SEC2_CI	Sensor instrumentation and integration
		Core course	SEC2_COMP	Compilation
		Core course	SEC2_CPP	Object-oriented programing
UE205	4			
		Core course	SEC2_ANG	English
		Core course	SEC2_PSI	Internship Abroad / Project Internship

Analysis of Professional Practices [SEC2_ADP]

LEAD PROFESSOR(S): Marie GOUGEON

Objectives

▪ Understand the value of the business mission over the past year.
▪ Validate his/her knowledge of the dimensions of the engineer in charge of a mission, based on the elements of his/her experience, his/her feedback
▪ Enable apprentices to move from a student position to a professional position through:
▪ Reflection on their learning methods and methodologies,
▪ Identification of efficient practices,
▪ An exchange between peers,
▪ Linking the two training venues: the school and the host company.

Course contents

Examples of themes: The integration of the apprentice into a company,
▪ Use of information and communication tools,
▪ In-school training,
▪ Peer-to-peer training,
▪ Ownership of the training system.

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1)

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

Business Skills [SEC2_ENT]

LEAD PROFESSOR(S): Olivier Henri ROUX

Objectives

Apprenticeship training

Course contents

Apprenticeship training approximately 4-5 weeks

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1)

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

Preparation of final project [SEC2_PFE]

LEAD PROFESSOR(S): Marie GOUGEON

Objectives

Course contents

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1)

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

Social challenges for the companies [SEC2_ESE]

LEAD PROFESSOR(S): Stéphane GUYARD

Objectives

Course contents

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

Social Sciences Applied to the Workplace [SEC2_SSAT]

LEAD PROFESSOR(S): Fabien THOMAS

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	-	54 hrs	0 hrs	0 hrs	0 hrs	0 hrs

Business Economics [SEC2_EE]

LEAD PROFESSOR(S): Jean GUERNIC

Objectives

Course contents

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	-	28 hrs	0 hrs	0 hrs	0 hrs	0 hrs

Embedded Linux [SEC2_LE]

LEAD PROFESSOR(S): Mikael BRIDAY

Objectives

* basic use of the command line
* understanding an industrial embedded Linux system
* Cross compilation : configure and compile your own kernel, flash, boot, update...
* Develop your own applications
* Develop Linux kernel drivers according to the Device Tree principle: be comfortable with the notion of kernel / user space, DTS, interrupts,...
* industrial application development

Course contents

* use of the terminal
* development on embedded target (user space)
* drivers development (kernel space)
*whole application development on Pegase 3

Course material

* Linux embarqué - Pierre Ficheux, éditions Eyrolles - 2016
* solutions temps réel sous Linux - Christophe Blaess - 2015
* Linux - Maitrisez l'administration du système - Sébastien Rohaut - 2020

Assessment

Collective assessment: EVC 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	-	6 hrs	4 hrs	32 hrs	0 hrs	0 hrs

Smartphone programming [SEC2_PS]

LEAD PROFESSOR(S): Pierre-Emmanuel HLADIK

Objectives

The goal of this course is to learn how to program on a smartphone or tablet.

Instructions will be on Android and in Java with Android Studio.

At the end of the course, students will be able to:
- design and program a user interface
- understand and implement data persistence
- build a concurrent application
- interconnect an application on a smartphone via a network

Course contents

Lectures and tutorials cover the following points:
- specificity of programming on Android
- component of a graphical interface
- data persistence
- concurrent programming on Android
- setting up a network communication

All the concepts will then be implemented through lab work and the implementation of an application for monitoring an embedded system.

Course material

Assessment

Collective assessment: EVC 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	-	10 hrs	0 hrs	20 hrs	0 hrs	0 hrs

Real-time programming [SEC2_PTR]

LEAD PROFESSOR(S): Olivier Henri ROUX

Objectives

Embedded systems are subject to numerous constraints and are in close interaction with processes. Some embedded systems, for example in avionics or automotive, are particularly critical and have strong real time constraints.
The objective of this course is to approach these embedded systems at 2 levels of abstraction
- with a direct programming on embedded board;
- by using a real-time operating system (RTOS) which offers higher level services;

In the latter case, multi-task programming and synchronization mechanisms between tasks are addressed.

Course contents

Use of a RTOS
- Functional decomposition of embedded systems ;
- Software architecture of a control system;
- Synchronous and asynchronous implementation ;
- General structure of a RTOS ;
- Synchronization, event and time management primitives;
- Examples of Real-Time applications.
- Real-Time Scheduling
- From single core to multi-core

Course material

- D. Patterson & J. Hennessy, Computer Organization and Design – ARM Edition, Morgan Kaufmann, 2017

Assessment

Collective assessment: EVC 1 (coefficient 0.6)

Individual assessment: EVI 1 (coefficient 0.4)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	-	10 hrs	0 hrs	20 hrs	0 hrs	0 hrs

Construction of an RTOS [SEC2_RTOS]

LEAD PROFESSOR(S): Pierre MOLINARO

Objectives

This course presents the step-by-step construction of a real-time kernel for an ARM processor, in about fifteen steps. For each step, the presentation is followed by immediate application by programming a microcontroller board.

The programming language is C++, and to a lesser extent ARM assembler.

At the end of this course, students will have understood the structure of a Real-Time kernel, hardware and software interrupts, how to write an executive service and a synchronization tool such as Dijkstra's semaphore.

Course contents

- Installation of the development chain
- Flashing LED
- software modes
- Real Time Interrupt SysTick
- User LEDs
- Push buttons
- LCD display
- SVC call
- Structure of an executive core
- Launching a single task
- Preemption
- End of tasks
- Waiting for a delay
- Semaphore
- Wait for deadline
- Buffer LCD display
- Multiple wait primitive

Course material

Système d'exploitation Temps Réel : https://en.wikipedia.org/wiki/Real-time_operating_system

Joseph Yiu, The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors, Newnes editor, ISBN-13 978-0124080829

Assessment

Collective assessment: EVC 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	-	10 hrs	20 hrs	0 hrs	0 hrs	0 hrs

Computer security [SEC2_SI]

LEAD PROFESSOR(S): Mikael BRIDAY

Objectives

- security in embedded systems
- hardware peripherals available to make secure code
- programming techniques to secure code in a microcontroller

Course contents

- general introduction to security
- hardware related to security (ARM trustzone in particular)
- programming techniques related to security (side attack channel, consumption analysis attack)
- implementation of a secure link (SHA256 hash / AES256+CDC encryption) in the Segger embbeded Studio environment

Course material

- datasheet SAML11, SAMD10
- SAM L11 Security Reference Guide AN5365
- Definitive Guide to Arm Cortex-M23 and Cortex-M33 Processors by Joseph Yiu
- https://www.ssi.gouv.fr/guide/regles-de-programmation-pour-le-developpement-securise-de-logiciels-en-langage-c/

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	-	16 hrs	10 hrs	0 hrs	0 hrs	0 hrs

Interconnected Systems [SEC2_SINT]

LEAD PROFESSOR(S): Pierre-Emmanuel HLADIK

Objectives

The objective of this course is to understand how to perform data exchange between microcontrollers: asynchronous serial link, I2C bus, SPI and CAN, Ethernet, Wifi, Bluetooth, etc.

The course and the practical classes are based on Adafruit Feather M0 Wifi and Teensy 3.6 boards, programmed via the Arduino IDE.

At the end of the course, students will be able to:
- understand the main ways of exchanging data between systems in a heterogeneous embedded architecture,
- implement different technologies (asynchronous serial link, I2C bus, SPI, CAN, Ethernet, WiFi, etc.) for data exchange,
- design the software infrastructure ensuring communication in a heterogeneous platform.

Course contents

The course introduces different communication media for embedded systems and follows the following outline:
- Introduction to the interconnection of systems
- Asynchronous serial link
- I2C bus
- Transmission lines
- SPI bus
- CRC (Cyclic Redundancy Checksum)
- CAN (Controller Area Network)
- Ethernet and TCP/IP protocol stack
- Bluetooth (Low Energy)
- WiFi link

The different concepts covered during lectures and tutorial sessions are then put into practice in practical sessions and via an integration project.

Course material

Assessment

Collective assessment: EVC 1 (coefficient 0.5)

Individual assessment: EVI 1 (coefficient 0.5)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	-	18 hrs	16 hrs	26 hrs	0 hrs	2 hrs

Actuators and Control Laws [SEC2_ALC]

LEAD PROFESSOR(S): Mohamed Assaad HAMIDA

Objectives

Cet enseignement propose:
- la formalisation mathématique des signaux et systèmes à temps continu;
- les bases du pilotage des systèmes dynamiques.

Course contents

Course material

Assessment

Collective assessment: EVC 1 (coefficient 0.4)

Individual assessment: EVI 1 (coefficient 0.6)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	-	18 hrs	12 hrs	24 hrs	0 hrs	2 hrs

Electronic Circuit [SEC2_CE]

LEAD PROFESSOR(S): Mikael BRIDAY

Objectives

- complete study of an embedded application, including a microcontroller
- electronic design of a board, schematic/routing
- low level programming with code size constraints (assembly)
- assembly, debugging and testing of the board.
- use of CAD tools Kicad, Freecad.

Course contents

- electronic design
- PCB schematic/routing
- soldering of components
- electronic debug
- programming
- validation of the board

Course material

https://www.kicad.org/

Assessment

Collective assessment: EVC 1 (coefficient 0.4)

Individual assessment: EVI 1 (coefficient 0.6)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	-	10 hrs	14 hrs	0 hrs	0 hrs	2 hrs

Sensor instrumentation and integration [SEC2_CI]

LEAD PROFESSOR(S): Mira RIZKALLAH

Objectives

- Analyse general concepts related to sensor and their physical principles
- Explain the usage of sensors in a measurement setup
- Know the main steps of data acquisition and signal processing for the extraction of the useful information
- Study some examples related to physical process monitoring using techniques from automatic control

Course contents

1. General principles of sensors
2. Metrological characteristics of sensors
3. Sensor conditioning for measurement
4. Instrumentation and data acquisition
5. Data analysis by signal processing
6. Application to control systems

Course material

Les capteurs en instrumentation industrielle. Georges Asch, Dunod, 2002
LabVIEW : Programmation et applications. Francis Cottet, Dunod, 2008
Control System Design, G.C. Goodwin, S.F. Graebe, M.E. Salgado, Prentice Hall, 2001.

Assessment

Collective assessment: EVC 1 (coefficient 0.4)

Individual assessment: EVI 1 (coefficient 0.6)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	-	18 hrs	16 hrs	20 hrs	0 hrs	2 hrs

Compilation [SEC2_COMP]

LEAD PROFESSOR(S): Pierre MOLINARO

Objectives

This course aims to give students an overview of compilation tools and techniques. During a long tutorial students will build a complete compiler of a small toy language, from the lexical analyzer to the LLVM code generation.

Course contents

- Introduction
- The different phases of compilation
- Use of GCC and binutils
- Cross compilers
- Use of LLVM - CLANG
- Lexical analysis
- Syntactic analysis
- Building the abstract syntax tree
- Semantic analysis
- Sections, assembler and link editing
- Cortex-M4 assembler
- The LLVM language

Course material

Alfred V. Aho, Monica S. Lam, Ravi Sethi. Compilers: Principles, Techniques, and Tools (2nd edition). Addison Wesley. 2006

Legendre Romain, Schwarzentruber François, Compilation : analyse lexicale et syntaxique - Du texte à sa structure en informatique, édition Ellipses, ISBN :
9782340003668

Kai Nacke, Learn LLVM 12, éditeur Packt Publishing, ISBN : 9781839210037

Assessment

Collective assessment: EVC 1 (coefficient 0.5)

Individual assessment: EVI 1 (coefficient 0.5)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	-	10 hrs	20 hrs	0 hrs	0 hrs	2 hrs

Object-oriented programing [SEC2_CPP]

LEAD PROFESSOR(S): Myriam SERVIERES

Objectives

This course aims to deepen the elements of C++ programming. It starts with a review of the notions of object design, writing classes, and using STL. Then it deals with multiple inheritance, exceptions, templates and ends with an introduction to multi-threaded programming and the challenges of parallelism.

In order to master the language in an operational way, a large number of practical exercises are planned.

Course contents

- object design, class writing, and STL
- Multiple inheritances
- exceptions
- templates
- Introduction to multi-threaded programming and parallelism issues

Course material

Assessment

Collective assessment: EVC 1 (coefficient 0.5)

Individual assessment: EVI 1 (coefficient 0.5)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	-	8 hrs	0 hrs	24 hrs	0 hrs	0 hrs

English [SEC2_ANG]

LEAD PROFESSOR(S): James RATCLIFF

Objectives

▪ prepare students for TOEIC test (grammar, vocabulary, listening, reading). Required TOEIC score: 750

If students have been unable to carry out foreign internship at the end of first 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
Les Guides Officiels du Test TOEIC. Grammaire Vocabulaire du Test TOEIC - Hachette
L'intégrale TOEIC - Nathan
200% TOEIC 2021 - Ellipses

Assessment

Individual assessment: EVI 1 (coefficient 1)

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

Internship Abroad / Project Internship [SEC2_PSI]

LEAD PROFESSOR(S): Alan BALL

Objectives

Course contents

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1)

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