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# ENGINEERING PROGRAMME

2023-2024

Year 3

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Professional Option  
**Science and Music**

OP SCIMUS

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PROGRAMME SUPERVISOR

Jean-François PETIOT



ENGINEERING - OP SCIMUS

# Autumn Semester

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Course unit	ECTS Credits	Track	Course code	Title
UE 92	4	Core course	ACSIP MUNUM	Acoustics, Signal, Perception Digital music

# Spring Semester

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Course unit	ECTS Credits	Track	Course code	Title
UE 102	1	Core course	ACMUS PROMU	Musical acoustics Project

## ENGINEERING - OP SCIMUS

Year 3 - Autumn Semester - Course Unit 92

# Acoustics, Signal, Perception [ACSIP]

LEAD PROFESSOR(S): Jean-François PETIOT

## Objectives

To present the tools and methods to represent, analyse and synthesize audio signals.

Basics of acoustics and sound propagations

Introduction to psychoacoustics and the study of sounds as perceived by humans.

## Course contents

a) Basic tools for audio signal processing

- Classification of sounds

- spectral analysis - time-frequency representation - spectrogram - audio filtering

- digital sound

b) Basic acoustics

- Sound sources - Propagation - wave equation

- dimensions (intensity, power, decibels)

- the audio chain - captors - transducers - peripherals

c) Introduction to Psychoacoustics

- auditory physiology

- sound perception

- Masking effect - critical bands - auditory scenes organisation - audio streams - cocktail effect

- shepard sounds

- Psychoacoustic metrics (dBA, loudness, sharpness, roughness)

Listening tests and perceptual experiments (psychometry)

Analysis of perceptual data

- multidimensionnel analysis (ACP, MDS)

- Analysis of variance and statistical tests

- Signal detection theory

5 labs

Lab 1: sound analysis - example of additive synthesis - filtering - soustractive synthesis - sound effects (Matlab or Python)

Lab 3: masking effect - beats - perpetual scales - musical temperament

Lab 3: Audacity - audio editing - effects - sound design and synthesis

Lab 4: Data analysis of audio tests

Lab5 : Psychoacoustical Tests - Signal detection theory

## Course material

Philippe GUILLAUME. Musique et acoustique - de l'instrument à l'ordinateur, Hermès, Lavoisier, 2005.

Olivier CALVET. Acoustique appliquée aux techniques du son. Educavivre, Casteilla 2002

Michèle CASTELLENGO. Ecoute musicale et Acoustique. Eyrolles, 2015.

## 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	2	16 hrs	0 hrs	16 hrs	0 hrs	0 hrs

## ENGINEERING - OP SCIMUS

Year 3 - Autumn Semester - Course Unit 92

### Digital music [MUNUM]

*LEAD PROFESSOR(S): Jean-François PETIOT*

#### Objectives

The digital music course offers specialized training in computational methods for music analysis and musical creation. It covers algorithms for the automatic processing of musical files, both in symbolic (i.e., sheet music) and audio formats. In doing so, the course gives an opportunity to learn about classical techniques in pattern machine and artificial intelligence.

At the end of the course, the student will be able to :

- design and operate digital audio effects ;
- extract audio features to retrieve similarities between musical recordings ;
- apply artificial intelligence systems to the identification of repeated patterns in musical recordings as well as sheet music.

#### Course contents

Outline :

- Digital audio effects : An ear for mathematics
- Audio content analysis : Organizing large digital audio archives
- Sheet music analysis : Structure retrieval and discovery of repeated patterns
- Music and data : Musical production in the XXIth century

Practicals (4 sessions) :

TP1 : Digital Audio Effects (Faust)

TP2 : Music Information Retrieval (Python)

TP3 : Discovery of motifs in sheet music of Bach sonatas (Python)

TP4 : Music structure analysis of Piano recordings (Python)

#### Course material

- DAFX - Digital Audio Effects, Udo Zölzer, John Wiley & Sons, 2002
- Fundamentals of Music Processing, Audio, Analysis, Algorithms, Applications ; Müller, Meinard, Springer (<https://musicinformationretrieval.com>)
- An Introduction to Audio Content Analysis: Applications in Signal Processing and Music Informatics: Alexander Lerch

#### 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	2	16 hrs	16 hrs	0 hrs	0 hrs	0 hrs

## ENGINEERING - OP SCIMUS

Year 3 - Spring Semester - Course Unit 102

# Musical acoustics [ACMUS]

LEAD PROFESSOR(S): Jean-François PETIOT

### Objectives

To present the main principles governing how musical instruments work and their design:

- wind
- strings (violin - piano)
- percussion

To give basics on room acoustics.

To present an overview of the History of music.

### Course contents

Part 1 - Musical instruments - systemic and organological study - physical models

- specifications of a musical instrument
- a) The functioning of musical instruments
- auto-oscillations
- free vibrations

Excitator and resonator

b) Different categories of instruments

- winds (reeds, flutes, singing voice)
- string (violin, piano)
- percussion

The input impedance of wind instruments

modal analysis of string instruments

Materials

Part 2 - Room acoustics

- Objective characterization of rooms - isolation
- models in room acoustics
- soundscape and quality of rooms
- Sound engineering

Part 3 - Sound production - mixing

sound mixing - peripherals - sound effects

Labs (4 sessions)

Lab 1: physical modeling of violin - sound simulations

Lab 2: physical modeling of brass instruments - sound simulations

Lab3: comparison of instruments.

Lab 4: exercise on a multitrack mixing (LMMS software)

### Course material

Emile LEIPP. Acoustique et Musique. Masson, 1989.

Michèle CASTELLENGO. Ecoute musicale et acoustique. Eyrolles, 2015.

Philippe GUILLAUME. Musique et acoustique. Hermes, Lavoisier 2005.

M.CAMPBELL, J.GILBERT et A.MYERS. The science of brass instruments " ed. Springer-Verlag, 2021

## Assessment

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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	0.5	20 hrs	12 hrs	0 hrs	0 hrs	0 hrs



## ENGINEERING - OP SCIMUS

Year 3 - Spring Semester - Course Unit 102

### Project [PROMU]

*LEAD PROFESSOR(S): Jean-François PETIOT*

#### Objectives

To apply a scientific approach to a musical field.

#### Course contents

Students can choose their own project, the subject of which must be related to the different aspects covered in the option:

- physics of musical instruments, physical models
- innovative musical instruments
- control of room acoustics
- sound recording, sound engineering, musical project
- automatic scores
- micro web-based services for browsing and musical creation
- MIR (music information retrieval)

#### Course material

#### Assessment

Collective assessment: EVC 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	0.5	0 hrs	0 hrs	0 hrs	40 hrs	0 hrs