

**2020/2021 – M2 IMDEA Course Plan
Semester 1**

Teaching Unit	Course	Contents	Working hours	ECTS
Acoustics	3D sound	Spatial perception (how the auditory system localizes sounds), stereophony and multichannel audio. Binaural technology, Holophony and WaveField Synthesis, Ambisonics and Higher Order Ambisonics. Principle of sound zones controls	20	2
Electroacoustics	Electrodynamic motors	Basics of magnetism (Magnetic field, Electromagnetism, Magnetic materials, Ferromagnetic materials) Application of magnetism to loudspeaker motor design (magnetostatics, voice coil design) 2D FEM modelling of motors (with free software FEMM)	24	2
	Loudspeaker modelling	Lumped parameter modelling and measurement, state space modelling of linear systems (Loudspeaker, loudspeaker in vented box) Modelling of non linear effects in loudspeakers. Study of THD and IMD. State space modelling of nonlinear loudspeaker. Physical causes and nonlinear symptoms, Diagnostics on regular large signal performance, Diagnostics on irregular loudspeaker defects, Power Handling, Heating, Aging, Climate, Meaningful Loudspeaker Specifications	20	2,5
	Microphone modelling	Modelling microphones response taking into account viscothermal effects	12	1
	Mini and micro transducers	General models of headphones and earphones (lumped elements model of the loudspeaker, model of the ear). Measurement techniques for mini and micro transducers (Microphones ECM and MEMS, Micro-speakers, Measurement hardware). MEMS microphones (history, design criteria, modelling, calibration)	10	1
	Radiation of transducers	Introduction to radiation. Elementary electroacoustic sources, principles of arrays, modelling array radiation. Python simulation of line array and end-fire array. Effect of baffle on radiation (scattering). Real loudspeaker array and interaction with a room. Radiation of horns. Radiation of Distributed Mode Loudspeakers	29	3
	Transducers measurements	Microphones measurements techniques (measurement microphone data sheet, relative calibration, absolute calibration). Loudspeakers measurement techniques (advanced approaches in measurements using a sound card and a programming platform, advanced approaches in loudspeaker measurements leading to models at higher levels). Practicals on measurement systems, loudspeakers, headphones and microphones.	26	3
Professional	Advanced Transducer Project	The project aims at studying an electroacoustic system for real life applications or for research applications (literature review, analytical modelling, numerical modelling, experiments).	36 + 100 Work in Autonomy	6
Signal Processing & Electronics	Adaptive filtering	The aim of this course is to master digital signal processing techniques for advanced audio applications (music, telecom, sensors array..) : Localisation, adaptive signal processing, echo cancellation.	20	2
	Power electronics	Overview of power supplies. Power amplifiers design. Currents converters	21	2
	Signal analysis II	Acoustic imaging with holography and beamforming Identification of measured FRF. Pisarenko, Prony methods, decomposition in subspaces	20	2,5
Vibroacoustics	Numerical Vibroacoustics	Introduction of BEM principles. Introduction to ABEC (Acoustic Boundary Element Calculator). Study of simple cases Simple models of acoustics in closed and opened systems by FEM and/or BEM approaches with Comsol. Computation of vibrations modes for structures and acoustic modes for closed cavities by FEM, vibroacoustic coupling on the solid / fluid interface, Applications to more complex systems.	36	3
			291 + 100 (project)	30

**2020/2021 – M2 IMDEA Course Plan
Semester 2**

Teaching Unit	Course	Contents	Working hours	ECTS
Electroacoustics	Electrodynamic motors	Loudspeaker system modelling with ABEC and Comsol	40	4
Professional	Master's thesis	5-month internship in a company working on an industrial problem dealing With design and/or characterisation of electroacoustic systems.	700	26
			740	30