Sound engineering course

		Teacher	Hours	Name
1.Acustics	Fundamentals of acoustics: nature of sound, physical quantities, propagation, point and line sources.	Farina	4	ACU1
	Psychoacoustics: sound levels in dB, sound perception, spectral analysis, phons, weighting curves		3	ACU2
	Outdoors acoustics: effects of temperature, humidity, wind, diffraction, shielding, air absorption		3	ACU3
	Indoors acoustics: reflection, transmission and absorption, semi-reverberant field, critical distance. Time history of sound, reverberation, reverberation time (RT).		3	ACU4
	Impulse Response measurement: Measurement of the Impulse Response and of the Acoustical Parameters. Workshop about measurement of impulse response and acoustical parameters in a room.		3	ACU5
2.Transducers	The Loudspeaker as Electroacoustic transducer 1. Why an Electroacoustic transducer? 2. Recalling of Sound Wave equation: plane waves and spherical waves, pressure and particle velocity, power radiation, Intensity. 3. Acoustic radiation from a simple source and a combination of 2 or more sources 4. The vibration of a rigid disc in a baffle and its acoustic properties, as a physical reference. 5. Vibration driving force as a magnetic-electric-mechanic interaction: theoretical transducer as a combination of a electromagnetic motor and a sound radiator. Main equation and motion study. Steady state behavior.	Ugolotti	4	TRA1
	Equivalent circuit of an Electro-dynamic Loudspeaker: 1. Acoustic-Mechanic-Electric complex system as theoretical transducer, transient response after the approximated model. 2. Toward a real loudspeaker and analysis to its real parts: a) sound radiator: vibration modes and diaphragms materials 2) motor: a) voice coil structure and design, b) Magnet materials, structure and design, c) spider and suspensions structure and design.		4	TRA2
	Electro-Dynamic Loudspeaker sound radiation analysis - direct radiation & enclosure loading: 1. Loudspeaker equivalent circuit and its main components: the Thiele-Small parameters. 2. Loudspeaker in a cabinet: closed box analysis 3. Loudspeaker in a cabinet: bass-reflex and passive radiator analysis, to increase efficiency at low frequencies 4. Examples to be given [possibly real products]: closed box and bass reflex (showing the ducts)		4	TRA3

	Exercise session [Design of a Bass-Reflex cabinet - Simulation with WINCROSS, Bass-Box or other Simulation SW]–		2	TRA4
	Electro-Dynamic Loudspeaker sound radiation analysis – Horn Loading : 1. Horn loading classical theory for low and mid low frequencies, for loudspeakers in a cabinet (folded horn and ¼ lambda horn) 2. Horn loading classical theory for mid and high frequencies: compression drivers a. compression structure to increase efficiency b. horn loading for adapting and matching the acoustic load 3. Examples to be given (existing folded horn subwoofer, horn-loaded midrange, compression drivers and horns) **4.** Advanced Horn Theory & Waveguides Quick Notes		4	TRA5
	Measurement Session [T/S and Impedance Curve measuring through CLIO]		2	MEAS 1
	Distortion Analysis & Measurements: 1. Distortion types 2. Distortion Main Causes analysis 3. Countermeasures against distortion: passive and active approaches		4	TRA6
	Loudspeaker systems: 1. Power handling & Thermal Behavior 2. Anechoic room & in-situ measurements 3. Impedance measurement 4. Innovative Measurements (Klippel method, Prof. Farina's Sine-sweep, TDS & MLSSA)		3	TRA 7
	Loudspeaker systems: 1. Topologies, materials and technologies 2. Multi-way systems and Cross-over filters; 3. Loudspeaker arrays. 4. Innovative Transducers		3	TRA 8
	Measurement Session [Klippel Measurement Session]		2	MEAS 2
3.Electronics	Introduction: electronic systems; analog and digital signals. Circuit analysis basic: Kirchoff and Ohm laws; Thevenin theorem, frequency response. Amplifier: linear amplifier basic concepts.	Larcher	3	ELE1
	Signal amplifiers: operational amplifiers. Filters: passive analog filters; active filters; Power signal amplifier topologies: MOSFET devices, common source and source follower topologies.		3	ELE2
	Power amplifiers basics: efficiency, distortion, matching, feedback stability and compensation.		2	ELE3
	Linear versus switching amplification and basic scheme of a class D amplifier: power losses considerations, PWM modulation, dead time insertion. No ideality that introduce THD.	Lorenzani	3	PA1
	Audio switching topologies: half bridge and full bridge, other Amplifier classes, series and parallel hybrid amplifier. Advantages and disadvantages.		3	PA2

	Class D amplifier control. Open loop and closed loop operations. Voltage and current feedback. Self-oscillating class-D power amplifiers. Output filter considerations. Brief EMI consideration.		3	PA3
	New trends in audio amplification: multilevel solutions, sigma-delta modulation. Examples of voltage/current waveforms of different kind of switching audio amplifiers.		3	PA4
	Fundamental of Digital Signal Processing 1: Discrete-Time signal & systems Linear time-invariant (LTI) systems and linear convolution LTI systems properties Linear constant-coefficient difference equations		2	DSP1
	Fundamental of Digital Signal Processing 2: Frequency-domain representation of discrete time signals & systems Representation of sequences by Fourier Transforms The Discrete time Fourier transform (DTFT) The z-Transform		2	DSP2
	Digital signal Processor: Internal Architecture. Commercial DSP. Fixed vs floating architecture Commercial A/D and D/A: how to choose and how to read a datasheet Sample vs block processing Examples with Analog Devices demo board	Trestino	5	DSP3
	Fundamental of Digital Signal Processing 3: Audio Effects Delay based effects Non-linear processing		3	DSP4
	Fundamental of Digital Signal Processing 4: Structures for Discrete-Time Systems: Filter design techniques Discrete-time IIR filters design from continuous-time filters Discrete-time filters design by windowing Audio filters Equalizers, tunable filters		3	DSP5
	DSP & audio filtering exercise: A real case: TTL33 implementation Examples with Analog Devices demo board		5	DSP6
4.Sound systems -	Sound Reinforcement System Design: Analysis of the signal path: sources(microphones), signal processing (signal levels, preamplifiers, mixers, equalizers, dynamic controllers), wires, acoustic transmission, acoustic gain. Sound Reinforcement Systems Design: Interaction with real world: summation, speaker-speaker interaction, speaker-room interaction. Reception: localization; tonal, spatial and echo perception. Multi-channel systems.	Begotti	4	SDS1
	Sound Reinforcement Systems Design: Design principles, goals and challenges. Centralized, distributed system, sub-systems. Acoustic simulation software: how they work, relevant results. Overview of EASE acoustic simulation software	Begotti	4	SDS2
	Sound reinforcement systems design: , Line array : 1. Line array as an integration from the multy way system	Nizzoli	4	SDS3

	concept and multiple source directivity control. 2. Equalization , total gain of the system , audio chain. Line array system example. Speaker Lab software is used to re-design the Array from the acoustic baloon measurements of the single loudspeakers , EQ curves and delays , geometry positioning of the single components relative to the array , directivity control with dsp. Exploring different design choice			
	Sound Reinforcement Systems Design: how to design a sound system by using EASE 4.3 acoustic simulation software; introduction to architectural modeling. - Case Study: Delle Alpi Stadium: working on existing models it will be discussed about selecting and positioning the speakers and how to optimize the system. Analysis of the final results	Begotti	4	SDS4
	Sound reinforcement systems design: simulation exercise	Begotti	3	SDS5
	Sound reinforcement systems design: Indoor system measurement/optimization: setting a sound system, equalization, phase alignment, crossover, delay (using SMAART/EASERA)	Begotti/Cilloni	3	SDS6
	Sound Reinforcement Systems design: audio networking. Technologies and infrastructures required. Transmission protocols. Applications and examples.	Zanghieri	5	SDS7
	Final exercise in open field (Line Array set-up)	Cilloni/Begotti	5	SDS8

Calendar

1st week

	5th of May	6th of May	7th of May	8th of May	9th of May
08:00-09:00			Free study	SDS1	
09:00-10:00	Welcome	ELE2			ELE3
10:00-11:00	ELE1				
11:00-12:00					
12:00-13:00					
13:00-14:00			ACU1		
14:00-15:00	Free study	PA1		ACU2	PA2
15:00-16:00					
16:00-17:00					

2nd week

	12rn of May	13rd of May	14th of May	15th of May	16th of May
08:00-09:00	ACU3		ACU5	SDS2	Free study
09:00-10:00		ACU4			
10:00-11:00					
11:00-12:00	DSP1		DSP2		
12:00-13:00					
13:00-14:00					TRA1
14:00-15:00	Free study	PA3	Free study	PA4	
15:00-16:00					
16:00-17:00					

3rd week

	19th of May	20st of May	21st of May	22nd of May	23rd of May
08:00-09:00	DSP3	TRA2	TRA3	SDS3	TRA4
09:00-10:00					
10:00-11:00					MEAS 1
11:00-12:00					
12:00-13:00					
13:00-14:00					TRA5
14:00-15:00	Free study	DSP4	Free study	DSP5	
15:00-16:00					
16:00-17:00					

4th week

	26th of May	27th of May	28th of May	29st of May	30th of May
08:00-09:00	DSP5			SDS4	TRA6
09:00-10:00		SDS5	SDS8		
10:00-11:00					
11:00-12:00					
12:00-13:00					
13:00-14:00					
14:00-15:00	Free study	SDS6	Free study	Free study	TRA7
15:00-16:00					
16:00-17:00					

5th week

	2nd of June	3rd of June	4th of June	5th of June	6th of June
08:00-09:00	Free study	TRA8	SDS7	Free study	Final exam
09:00-10:00					
10:00-11:00					
11:00-12:00		MEAS 2			
12:00-13:00					Lunch and adjourn
13:00-14:00					
14:00-15:00		Free study	Free study		
15:00-16:00					
16:00-17:00					