COURSE OUTLINE

(1) GENERAL

SCHOOL	ENGINEERING		
ACADEMIC UNIT	ELECTRICAL AND COMPUTER ENGINEERING DEPT.		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	**ECE_TEL860**	**SEMESTER**	**8**
COURSE TITLE	SOUND AND MUSIC PROCESSING		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	3	
Laboratory	1	
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (4).	4	5

COURSE TYPE *general background, special background, specialised, general knowledge, skills development*	Specialised
PREREQUISITE COURSES:	This course has no prerequisite courses. However, the students should have prior knowledge of: • PROBABILITY AND STATISTICS • DIGITAL SIGNAL PROCESSING
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK AND ENGLISH
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	https://www.ece.uop.gr/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning*

and Appendix B

- *Guidelines for writing Learning Outcomes*

The aim of the course is to introduce students to the basic concepts, techniques and methodologies used to solve problems in the field of digital audio and music processing. Specifically, the course consists of three parts: audio processing, music processing and music information retrieval. The first part presents an introduction to sound signals and the different types of sounds. The ways of sound generation and transmission are presented. In addition, the fundamental principles of the acoustic theory and room acoustics are also presented. The course covers the topics of sound perception and cognition by humans. Basic audio processing techniques based on the area of digital signal processing are finally presented. The second part deals with music and the description of main features and descriptors. In the last part of the course, the techniques and algorithms for music information retrieval are presented. Basic music recognition and processing systems are presented, such as music instrument recognition, emotion recognition, music track recognition, music genre, etc.

Keywords: Audio editing, music information retrieval, music genre recognition, music emotion, room acoustics, blind signal separation, sound decomposition, audio cancellation, audio fingerprinting

Learning outcomes

Upon successful completion of the course, students will be able to:

At the knowledge level:

- Know the different types of sound.
- Understand how sound is generated and transmitted.
- Be familiar with basic sound signal transformations
- Know basic filters and their application in audio signal filtering
- Understand the way in which sound is transmitted indoors and outdoors
- Understand how humans perceive sounds
- Know the main descriptors in the time and frequency domain of audio signals.
- Understand basic audio processing applications
- Know basic characteristics of music signals
- Understand the structure of musical pieces
- Know how an audio fingerprint can be extracted and its role
- Understand how similarity is measured between different pieces of music
- Understand how music track recognition systems work
- Understand how music recommendation systems work.
- Understand basic recognition systems of musical characteristics such as song instruments, song emotion, song genre, etc.

At the skill level:

- Design basic filters for sound signal processing
- Design environments with controlled acoustical behavior
- Calculate the change in sound signals when they are transmitted indoors
- Calculate basic sound signal characteristics and features (descriptors)
- Design and implement basic sound processing techniques and algorithms
- Calculate important descriptors of songs and music using appropriate algorithms.
- Calculate and analyze the structure of musical signals
- Calculate fingerprints of songs
- Design techniques for retrieving music information.

At the level of abilities:

- Select the appropriate parameters to export audio features for audio processing problems
- Choose appropriate parameters for the design of acoustic environments.
- Apply appropriate algorithms to improve sound quality (noise cancellation, simultaneous signal separation, echo cancellation).
- Select the appropriate parameters for exporting music descriptors for music content retrieval problems
- Recognize important parts in musical pieces and songs and segment the musical pieces accordingly.
- Collectively use theory to solve complex problems in the field of sound and music processing.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and *Project planning and management*

information, with the use of the necessary technology	*Respect for difference and multiculturalism*
Adapting to new situations	*Respect for the natural environment*
Decision-making	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Working independently	*Criticism and self-criticism*
Team work	*Production of free, creative and inductive thinking*
Working in an international environment	*……*
Working in an interdisciplinary environment	*Others…*
Production of new research ideas	*…….*

- Search for, analysis and synthesis of data and information, with the use of the necessary technology.
- Decision-making
- Work independently
- Teamwork
- Work in an international environment
- Production of free, creative and inductive thinking

(3) SYLLABUS

Brief description

The course consists of three parts: audio processing, music processing and music information retrieval for the engineer.

Theory lectures

1. Introduction to audio signals.

Types of sound. Ways of creation - ways of transmitting sound. Key audio features. Basic audio processing algorithms. Frequency transforms. The discrete cosine transform. The discrete wavelet transform. Digital filters for digital audio processing. Time-varying filters. Equalizers.

2. Room acoustics.

Description of room acoustics. HRTF head transfer functions. Sound reverberation. Room acoustics design. Comparison of the acoustic of different environments.

3. Perception of sound by man (perception - cognition).

Description of sound perception process. Psychoacoustics. Absolute hearing threshold. Critical bands.

4. Audio descriptors - Extract parameters

Basic sound descriptors in the time domain. Signal energy. Zero Crossings. Entropy of energy. Audio descriptors in the frequency domain. Spectral Centroid. Spectrum entropy. Spectrum flow. MFCC. Chroma. Estimation of periodicity and harmony.

5. Basic audio processing applications

Sound signal processing with multiple microphones: echo cancellation, dereverberation, blind source separation.

6. Introduction to audio music signals.

Music representation. Representation via score. Symbolic representation. Acoustic representation. Key features of music signal: Timbre, pitch, amplitude, duration - The four moments.

7. Music descriptors – Feature extraction

Music descriptors. timbral, rhythm, pitch, harmony features. Dynamic Time Warping. Applications. Music track tempo analysis. Recognize a beat of a piece of music using dynamic programming.

8. Analysis of the structure of musical pieces

Basic principles. Self-similarity tables. Audio thumbnailing. System evaluation.

9. Music information retrieval

Introduction to music data mining. Information retrieval. Recognition. Clustering. Different approaches to music information retrieval. Song lyrics. Country of origin. Music covers.

10. Music Indexing

Music indexing. Comparison of different sources of music information. Text indexing. Combining different sources of music information.

11. Audio fingerprinting

Fingerprint extraction of a song. Fingerprint identification. Music fingerprint detection and identification systems.

12. Measurement of similarity of musical pieces

What is similarity? Why is it important? How can it be depicted? How is it calculated?

13. Music recognition systems - Applications

Recognition of musical instruments. Recognition of emotion and emotional state of musical pieces. Recognition of music genre. Recognition of songs. Cover song detection. Music recommendation systems.

Laboratory Exercises

The laboratory part of the course includes 6 laboratory exercises during the semester. In the laboratory, students will use both open source programs (Python, LibROSA, Essentia, Madmom, Marsyas) as well as proprietary packages (MATLAB) to solve problems in the field of audio and music processing.

1. Basic digital audio processing techniques
2. Simulation of the acoustics in virtual rooms
3. Basic audio processing applications
4. Introduction to music audio signals.
5. Feature extraction from musical tracks
6. Basic applications of music information retrieval

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face to face in class and in the laboratory. Distance learning via e-Class system (asynchronous tele-education)
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	• Slides for the teaching of the theoretical part of the course. • Laboratory guides for the laboratory education (one for every laboratory exercise). • Support of the learning process through the e-Class platform (for announcements concerning the course operating regulations, sharing of course's slides, supplementary material, announcements, links and bibliography, and the submission of the semester projects). • Interactive exercises • Specialized proprietary software (Matlab) and open source software (Python, LibROSA, Essentia, Madmom, Marsyas) for the laboratory education.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive*	

Activity	***Semester workload***
Theory lectures	39
Laboratory Exercises using special software	13
Preparation / Completion of Laboratory Exercises	13

teaching, educational visits, project, essay writing, artistic creativity, etc. *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	Independent study of lectures and bibliography	25
	Job description	10
	Project preparation	25
	Course Total	***125 hours (5 ECTS)***
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	**A. Evaluation of Theoretical Part:** Written 120-minute final exam that includes: a. Problem solving b. Multiple choice questionnaires c. Short answer questions d. Comparative evaluation of theory data **B. Evaluation of Laboratory work:** Submission of reports (one per laboratory exercise) by each student via e-class platform. **C. Assessment of Group External Work:** Presentation of an optional semester research project assigned to groups of no more than 4 students. In case of foreign students from exchange programs, the six-month work can be submitted in English. **Remarks:** • From the evaluation in the laboratory work, each student receives a PASS/FAIL mark. • In order to be able to participate in the evaluation of the theoretical part of the course, the student must have received a PASS mark in the laboratory work. • The final grade of the course is calculated from the average weighting of the theoretical part grade and the optional semester project with weighting factors of 70% and 30% respectively. • In case a student has not undertaken a semester project, the final grade of the course is calculated only by the grade of the final exam. • The evaluation is done in the Greek language. In case of foreign participant students from exchange programs, the evaluation is also done in English. • The presentation of the semi-annual work can also be done in the English language.	

(5) ATTACHED BIBLIOGRAPHY

Suggested bibliography:

In English

1. Muller M., Fundamentals of Music Processing, Springer International Publishing, Εκδότης HEAL-Link Springer ebooks, 2015 (ΚΩΔ. ΕΥΔΟΞΟΥ 73263687)

2. Giannakopoulos T., Pikrakis A., Introduction to Audio Analysis: A MATLAB® Approach, Academic Press; 1 edition, 2014
3. Weihs C., Jannach D., Vatolkin I., Rudolph G., Music Data Analysis: Foundations and Applications, Chapman & Hall/CRC Computer Science & Data Analysis, 2016
4. Li T., Ogihara M., Tzanetakis G., Music Data Mining, Chapman & Hall/CRC Data Mining and Knowledge Discovery Series, 2011
5. Lerch, A., An Introduction to Audio Content Analysis, John Wiley & Sons, 2012

Related academic journals:

1. Transactions on Audio, Speech, and Language Processing, IEEE/ACM
2. Computer Music Journal, IEEE
3. EURASIP Journal on Audio, Speech, and Music Processing, Springer