Theory and Engineering of Music

Course Code:

ME 485

Course Type:

Area Elective

Credits:

3

Theoric:

3

Practice:

0

Laboratory Hour:

0

ECTS:

5

Course Language:

English

Course Content:

This course is intended to awaken in engineering and science students an interest in the complex physical problems encountered in music and musical instruments. The coverage of subjects is also designed as an introduction to sound engineering. Technical subjects range from simple harmonic motion to intermediate level signal analysis, to related partial differential equations. Although superficial, a wide-ranging exposition to the theory and history of music is also presented. Basic experiments, computer applications, and projects accompany the theoretical coverage.

- Waves and Harmonics: Vibration, Harmonic Motion, Beats, Resonance, Damping, Sound, Introduction to Wave Mechanics, Vibrating Strings, Vibrating Air Columns, Vibrating Membranes.
- Fourier Theory − Physics of Musical Instruments
- Introduction to Musical Terminology and Notation

- Consonance and Dissonance
- Perception
- Digital Music
- The Orchestra

Goals

The objectives of this course is to introduce the principals of sound and acoustics as applied to musical instruments and music theory:

- A general perspective on acoustics and psychoacoustics
- An understanding of classical wave equation and music instruments
- An understanding of musical intervals from a mathematical point of view.
- Ability to calculate frequency of musical notes and frequency ratios.
- Ability to calculate open field acoustic properties
- An understanding of musical terminology and concepts, including orchestra.
- An understanding of digital music concepts

Learning Outcomes	Program Outcomes	Teaching Methods	Assessment Methods
1) Acquire knowledge wave mechanics, Fourier analysis, music theory, physics of musical instruments, digital music.	2,3	1,3	A,C
2) Ability to analyze acoustic properties, frequency ratios, reverberation ratio, and other similar quantifiable properties.	2,3	1,3	A,C
3) Ability to use software to analyze sound and music.	2	1,3	A,C

COURSE CONTENT		
Week	**Topics**	**Study Materials**
1	Waves and Harmonics: Vibration, Harmonic Motion, Beats, Resonance, Damping, Sound, Introduction to Wave Mechanics, Vibrating Strings, Vibrating Air Columns, Vibrating Membranes.	Lecture Notes
2	Fourier Theory: Fourier Series, Fourier Coefficients, Fourier Transform, Frequency Spectrum, Filters, Related Software (MATLAB, Octave, Audacity, GoldWave, …)	Lecture Notes

3	Physics of Musical Instruments: Vibration Characteristics, Vibration Modes, Tonal Quality, Subjective and Objective Quality Measures, Mechanical Structure of Musical Instruments, Making of Stradivarius. Mechanisms of Piano.	Lecture Notes
4	Introduction to Musical Terminology and Notation: Frequency, Pitch, Tone, Notes, History of Music, Clef, Sharps and Flats, Unison, Octave, Scales, Temperaments, Keys, Majors, Minors, Rhythm, Form, Melody, Harmony, Monophony, Polyphony, Compositions.	Lecture Notes
5	Consonance and Dissonance: Pythagoreans, Perfect fifth, Perfect Third, Just Intonation, Equal Temperament, Chords, Commas, Pentatonic Scale, Whole Tone Scale.	Lecture Notes
6	Perception: The Human Auditory System, Limits of hearing, Twotone perceptions, Complex tones, Chromatic tones, Missing fundamentals, Non-linear Effects, Helmholtz Theory.	Lecture Notes
7	- Digital Music: High-Fidelity, Sound Recording, Sound Reproduction, Digital Formats, Sound Systems, Synthesis (ADSR cycle), MIDI, Sound Engineering Concepts.	Lecture Notes
8	The Orchestra: Musical Instruments, History, Acoustics of Orchestral Halls, Arrangement of the Ensemble.	Lecture Notes
9	Waves and Harmonics: Vibration, Harmonic Motion, Beats, Resonance, Damping, Sound, Introduction to Wave Mechanics, Vibrating Strings, Vibrating Air Columns, Vibrating Membranes.	Lecture Notes
10	Fourier Theory: Fourier Series, Fourier Coefficients, Fourier Transform, Frequency Spectrum, Filters, Related Software (MATLAB, Octave, Audacity, GoldWave, …)	Lecture Notes
11	Physics of Musical Instruments: Vibration Characteristics, Vibration Modes, Tonal Quality, Subjective and Objective Quality Measures, Mechanical Structure of Musical Instruments, Making of Stradivarius. Mechanisms of Piano.	Lecture Notes
12	Introduction to Musical Terminology and Notation: Frequency, Pitch, Tone, Notes, History of Music, Clef, Sharps and Flats, Unison, Octave, Scales, Temperaments, Keys, Majors, Minors, Rhythm, Form, Melody, Harmony, Monophony, Polyphony, Compositions.	Lecture Notes

13	Consonance and Dissonance: Pythagoreans, Perfect fifth, Perfect Third, Just Intonation, Equal Temperament, Chords, Commas, Pentatonic Scale, Whole Tone Scale.	Lecture Notes
14	Perception: The Human Auditory System, Limits of hearing, Twotone perceptions, Complex tones, Chromatic tones, Missing fundamentals, Non-linear Effects, Helmholtz Theory.	Lecture Notes

RECOMMENDED SOURCES	
Textbook	Benson, D. J., MUSIC: A Mathematical Offering, Cambridge U. Press, 2007.
Additional Resources	Rigden, J. S., Physics and the Sound of Music, Wiley, 1985. Gelineau, R. P., Understanding Music Fundamentals, Prentice-Hall, 1987. Fletcher, N. H., and, Rossing, T. D., The Physics of Musical Instruments, Springer-Verlag, 1991. Pohlmann, K. C., Principals of Digital Audio, McGraw-Hill, 4th ed., 2000.

MATERIAL SHARING	
Documents	Syllabus, Weekly course schedule
Assignments	Homework assignments
Exams	None

ASSESSMENT		
IN-TERM STUDIES	**NUMBER**	**PERCENTAGE**
Midterm Exam	1	30
Assignments	5	30
Attendance	1	0
Total		**60**
CONTRIBUTION OF FINAL EXAMINATION TO OVERALL GRADE		40
CONTRIBUTION OF IN-TERM STUDIES TO OVERALL GRADE		60
Total		**100**

COURSE'S CONTRIBUTION TO PROGRAM								
No	Program Learning Outcomes		Contribution					
		NA	1	2	3	4	5	
1	Adequate knowledge in mathematics, science and engineering subjects pertaining to the relevant discipline; ability to use theoretical and applied knowledge in these areas in complex engineering problems.	**X**						
2	Ability to identify, formulate, and solve complex engineering problems; ability to select and apply proper analysis and modeling methods for this purpose.				**X**			
3	Ability to design a complex system, process, device or product under realistic constraints and conditions, in such a way as to meet the desired result; ability to apply modern design methods for this purpose.			**X**				
4	Ability to devise, select, and use modern techniques and tools needed for analyzing and solving complex problems encountered in engineering practice; ability to employ information technologies effectively.	**X**						
5	Ability to design and conduct experiments, gather data, analyze and interpret results for investigating complex engineering problems or discipline specific research questions.	**X**						
6	Ability to work efficiently in intra-disciplinary and multi-disciplinary teams; ability to work individually.	**X**						
7	Ability to communicate effectively in Turkish, both orally and in writing; knowledge of a minimum of one foreign language; ability to write effective reports and comprehend written reports, prepare design and production reports, make effective presentations, and give and receive clear and intelligible instructions.	**X**						
8	Recognition of the need for lifelong learning; ability to access information, to follow developments in science and technology, and to continue to educate him/herself.						**X**	
9	Consciousness to behave according to ethical principles and professional and ethical responsibility; knowledge on standards used in engineering practice.	**X**						

10	Knowledge about business life practices such as project management, risk management, and change management; awareness in entrepreneurship, innovation; knowledge about sustainable development.	**X**						
11	Knowledge about the global and social effects of engineering practices on health, environment, and safety, and contemporary issues of the century reflected into the field of engineering; awareness of the legal consequences of engineering solutions.	**X**						
12	Ability to work professionally in both thermal and mechanical systems areas, including design and realization.	**X**						
13	Ability to verify and validate numerical solutions to engineering problems.	**X**						

ECTS ALLOCATED BASED ON STUDENT WORKLOAD BY THE COURSE DESCRIPTION			
Activities	Quantity	Duration (Hour)	Total Workload (Hour)
Course Duration (Excluding exam weeks: 12x Total course hours)	16	3	48
Hours for off-the-classroom study (Pre-study, practice)	16	2	32
Midterms	1	4	4
Homework	5	6	30
Final examination	1	4	4
Total Work Load			118
Total Work Load / 25 (h)			4.72
ECTS Credit of the Course			5