



[RE-196] BASICS OF ACOUSTICS



Curriculum of the academic discipline (Syllabus)

Course details

Level of higher education	First (bachelor's)
Field of knowledge	17 - Electronics, automation, and electronic communications
Specialization	172 - Electronic communications and radio engineering
Educational program	All
Discipline status	Elective (F-catalog)
Form of higher education	Full-time
Year of study, semester	Available for selection starting from the 2nd year, spring semester
Scope of the discipline	4 credits (Lectures 18 hours, Practical 36 hours, Laboratory hours, Independent work 66 hours)
Semester control/control measures	Test
Class schedule	https://schedule.kpi.ua
Language of instruction	Ukrainian/English
Information about the course coordinator / lecturers	Lecturer: Nelin E. A. , Practical classes: Nelin E. A. , Independent work: Nelin E. A.

Course placement

https://drive.google.com/drive/folders/1wlOBr67QvsA3zOqjDKCVrBrRyToeyfVNmO4xM11Jai0qQE_I9_YbwWaCenKw8-DS1-q55LdO

Curriculum

1. Description of the academic discipline, its purpose, subject matter, and learning outcomes

Acoustic waves accompany us at all times. Thanks to acoustic waves, we can hear. Acoustic waves are widely used in signal processing devices. A separate area is acoustic systems, in particular high-quality ones. Knowledge of the physical and mathematical foundations of acoustics, the basics of Hi-Fi and Hi-End acoustic equipment design is necessary for radio engineers, as it broadens their understanding of the applied wave world that surrounds us and provides additional opportunities to apply their knowledge in practical work.

The aim of the course is to develop students' competencies in the field of the fundamentals of acoustics, acoustic elements and paths, methods of computer research of typical acoustic structures, and the basics of designing high-quality acoustic systems.

The subject of the course is the physical and mathematical foundations of acoustics, the basics of designing Hi-Fi and Hi-End acoustic equipment.

Program competencies

(GC 01) ability to think abstractly, analyze, and synthesize ("Intelligent Technologies of Radio Electronics" (hereinafter IT); "Information and Communication Radio Engineering" (hereinafter referred to as IC); "Radio Engineering Computerized Systems" (hereinafter referred to as RC);

(GC 02) ability to apply knowledge in practical situations (all OPs);

(GC 07) ability to learn and master modern knowledge (all OPs);

(PC 04) ability to perform computer modeling of devices, systems, and processes using universal application software packages;

(PC 15) ability to perform calculations in the process of designing structures and means of information and telecommunication networks, telecommunication and radio engineering systems, in accordance with technical specifications, using both standard and independently developed methods, techniques, and software tools for design automation;

(PC 16) ability to apply standard calculation methods in the design of telecommunications and radio engineering devices and systems;

Program learning outcomes:

(PLO 05) skills in evaluating, interpreting, and synthesizing information and data;

(PLO 12, PRN 13) apply fundamental and applied sciences to analyze and develop processes occurring in telecommunications and radio engineering systems;

(PLO 23) select and apply technical solutions and perform the necessary calculations for the implementation of digital and analog signal processing methods;

(PLO 24) use methods and techniques for developing analog and digital radio devices, systems, and components, taking into account requirements for quality, reliability, characteristics, and operating parameters.

Based on the results of mastering the course material, students will gain theoretical knowledge in the field of acoustics fundamentals, practical knowledge of modeling and designing acoustic paths, and the ability to apply the acquired knowledge in the development of new acoustic elements, structures, and systems.

2. Prerequisites and post-requisites of the discipline (place in the structural-logical scheme of training under the relevant educational program)

For successful mastery of the discipline, students must have knowledge of the disciplines "Physics," "Higher Mathematics," "Informatics. Part 1, Fundamentals of Programming and Algorithms," "Fundamentals of Circuit Theory."

3. Content of the discipline

The discipline is structurally divided into 5 sections:

- 1 Acoustic waves and their properties
- 2 Mathematical models of waves and acoustic media
- 3 Acoustic signals and their spectra. Acoustic matching
- 4 Physiological acoustics
- 5 Fundamentals of high-quality acoustic system design

4. Teaching materials and resources

Basic literature

1. Fundamentals of Acoustics. Textbook. - . Kyiv: Naukova Dumka, 2007. - 640 p.
2. Everest F. A., Pohlmann K. C. Master handbook of acoustics, 7th ed. - NJ: McGraw-Hill TAB, 2021. - 565 p.
3. Kinsler L. E., Frey A. R., Coppens A. B., Sanders J. V. Fundamentals of acoustics, 4th ed. - NJ: John Wiley&Sons, 2000. - 560 p.

Additional sources

1. Self D., Brice R., Duncan B., Hood J. L., Sinclair I., Singmin A., Davis D., Patronis E., Watkinson J. Audio Engineering. Amsterdam: Elsevier, 2009. - 907 p.

Educational content

5. Methods of mastering the academic discipline (educational component)

Lectures. List of key issues

1 Acoustic waves and their properties

- 1.1 Waves. Acoustic waves
- 1.2 Longitudinal, transverse, and surface acoustic waves
- 1.3 Branches of acoustics
- 1.4 Frequency ranges of acoustic waves
- 1.5 Acoustic wave-based frequency filters in mobile phones
- 1.6 Speed, length of acoustic waves, and acoustic impedance

2 Mathematical models of waves and acoustic media

- 2.1 Harmonic wave in one-dimensional space
- 2.2 Standing wave
- 2.3 Wave impedance. Acoustic wave impedance
- 2.4 Wave reflection

2.5 Interference of incident and reflected waves

2.6 Transmission line model

2.7 Properties of a long line segment

2.8 Fabry-Perot resonator

3 Acoustic signals and their spectra. Acoustic matching

3.1 Multibeam wave interference

3.2 Fourier transform

3.3 Spectra of typical acoustic signals

3.4 Acoustic matching with a quarter-wave layer

3.5 Acoustic matching by smooth impedance change. Exponential horn

4 Physiological acoustics

4.1 Frequency spectrum of noise

4.2 Frequency spectrum of musical sounds

4.3 Sound loudness

4.4 Dependence of loudness on frequency

4.5 Sound perception range. Speech and music ranges

4.6 Industrial noise

5 Basics of designing high-quality acoustic systems

5.1 Acoustic system

5.2 Distortion of acoustic signals. Amplitude-frequency distortion

5.3 Phase-frequency distortion

5.4 Acoustic system crossover filters

5.5 Typical characteristics of all-pass filters

5.6 Dynamic head design

5.7 Features of dynamic head operation

5.8 Parameters of a dynamic head. Mechanical parameters

5.9 Dynamic head parameters. Electrical and acoustic parameters

5.10 Types of acoustic design

5.11 Open acoustic design

5.12 Closed box

5.13 Phase inverter

5.14 Transmission line

5.15 Devialet acoustic systems

Topics of practical classes. Tasks are performed using computer modeling in a computer lab.

- 1 Calculation of the characteristics of acoustic wave reflection from the boundary between media with different acoustic properties
- 2 Investigation of the acoustic properties of a structure formed by two walls and a gap between them (window, room, or special structure)
- 3 Calculation of the acoustic matching characteristics of materials with a quarter-wave layer in the matching range with a given average frequency
- 4 Calculation of crossover filters for an acoustic system

6. Independent work of the student

In order to improve the quality of learning, a modular test and a homework test on the subject of the discipline are provided.

Policy and control

7. Academic discipline (educational component) policy

Requirements for students:

Attendance at lectures and practical classes is a mandatory part of studying the material.

- the lecturer uses their own presentation materials during lectures; uses Zoom to teach the material of the current lecture, conduct practical classes, provide additional information, assign homework assignments (HW), modular control work (MCW), etc.; a Telegram group is used to inform students and organize feedback.
- Questions may be asked during the lecture.
- To defend the HW, you must complete the tasks specified in it and make analytical conclusions.
- Bonus points are awarded for active participation in lectures and practical classes, independent completion of tasks in practical classes, and early completion of HW assignments.

8. Types of control and rating system for assessing learning outcomes

A student's rating consists of points for the following components.

1. Work in lectures and practical classes.
2. Completion of HW and MCW assignments.
3. Answers during the exam.
4. Bonus points.

The total weighted score for work in lectures and practical classes, completion of HW tasks during the semester is $R_S = 100$ points with the following assessment criteria.

Work in lectures – 1 point, total $9 \cdot 1 = 9$ points.

Work in practical classes – 1 point, total $18 \cdot 1 = 18$ points.

Completion of HW assignments – 13 (14 for assignment 4) points, total $13 \cdot 3 + 14 = 53$ points.

HW assignment assessment criteria (in parentheses for assignment 4):

9 points – satisfactory performance; 11

points — good performance;

13 (14) points – excellent performance.

Completion of the MCR task – 4 points, total $5 \cdot 4 = 20$ points. Bonus points:

for active participation in lectures and practical classes (in particular, 2..3 points for solving a problem, 5 points for a complex problem);

for early completion of a practical assignment (1 day before the set date – 2 points).

The rating scale for the discipline $RD = 100$ points and is formed from the total score for work during the semester (starting rating) RC and the credit component $R3$:

$$RD = RC + R3.$$

According to the above

$$RC = R_l + R_{pr} + R_{hw} + R_{mcw} + R_t,$$

where R_l – points for work in lectures; R_{pr} – points for work in practical classes; R_h – points for DKP; R_{mcw} – points for MKP;

R_t – incentive points.

The minimum value of $RC=56$; the maximum value (without R_t) $RC=100$. The credit component

accounts for 44% of the rating scale and is equal to

$R_t = 44$ points. Assessment system for the exam:

- answers to all questions on the exam are missing or contain gross errors and do not meet the minimum required level of mastery of the material — 0-8 points;
- correct answers to at least 25% of the exam questions — 9-17 points;
- correct answers to at least 50% of the exam questions — 18-26 points;
- correct answers to at least 75% of the exam questions — 27-35 points;
- comprehensive, well-reasoned answers to all exam questions —

36-44 points.

Conditions for admission to the exam: a student is admitted to the exam if they have a starting rating $RC > 0.56R_s$, i.e., RC 56 points, and has passed the DCR and MCR.

The total number of RD points is converted to a score according to the

100-95	Excellent
94	Very good
84	Good
74-65	Satisfactory
64-60	Sufficient
Less than 60	Unsatisfactory

Conditions for admission not met Not admitted

Table of correspondence between rating points and university scale grades

Number of points	Grade
100-95	Excellent
94	Very good
84	Good
74-65	Satisfactory
64-60	Sufficient
Less than 60	Unsatisfactory
Admission requirements not met	Not admitted

9. Additional information on the discipline (educational component)

Description of material, technical, and informational support for the discipline

The laboratory computer workshop is aimed at independent performance of typical calculations of acoustic elements and modeling of acoustic paths.

The working program of the academic discipline (syllabus):

Compiled by [Nelin E. A.](#);

Approved by the PRE Department (Minutes No. 06/2024 dated 06/27/2024)

Approved by the methodological commission of the faculty/research institute (protocol No. 06/2024 dated 28.06.2024)

