Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Department of Applied Radio Electronics

[RE-196] BASICS OF ACOUSTICS

Curriculum of the academic discipline (Syllabus)

Course details

Level of higher education	First (bachelor's)
Field of knowledge	G - Engineering, manufacturing, and construction
Specialty radio engineering	G5 - Electronics, electronic communications, instrument engineering, and
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 16 hours, Practical classes 30 hours, Laboratory work 74 hours)
Semester control/control measures	Credit
Class schedule	https://schedule.kpi.ua
Language of instruction	Ukrainian/English
Information about the course coordinator / lecturers	Lecturer: Nelin Ye. A., Lab: 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 (OPP "Intelligent Technologies of Radio Electronics" (hereinafter IT); OPP "Information and Communication Radio Engineering" (hereinafter referred to as IC); OPP "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 acquire modern knowledge (all OPs);

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

(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 created methods, techniques, and software tools for design automation (all OPP);

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

Program learning outcomes:

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

(PLO 12 (OPP IC), PLO 13 (OPP IT and RK) 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 (IT OPP);

(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 (OPP RK).

As a result of mastering the material of the discipline, students will gain theoretical knowledge in the field of acoustics fundamentals, practical knowledge of modeling and designing acoustic paths; they will acquire the ability to apply the knowledge gained 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&Suns, 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 segment of a long line

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 the dynamic head. Mechanical parameters

5.9 Parameters of the dynamic head. 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

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 by students

In order to improve the quality of learning, modular tests and homework assignments on the subject are provided.

Policy and control

7. Policy of the academic discipline (educational component)

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 the Zoom program to teach the material of the current lecture, conduct practical classes, provide additional information, assign homework tests (HWT), modular tests (MT), 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 assessment and the learning outcomes assessment rating system (LOAS)

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

1. Work in lectures and practical classes.
2. Completion of HCW and MCW assignments.
3. Answers during exams.
4. Bonus points.

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

Work in lectures – 1 point, total 9´1=9 points.

Work in practical classes – 1 point, total 18´1=18 points.

Completion of DCR assignments – 13 (14 for assignment 4) points, total 13´3 + 14=53

points. Assessment criteria for DCR assignments (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´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 practical assignments (2 points for completion 1 day before the deadline).

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

$$RC = R_л + R_{пр} + R_{ДКР} + R_{МКР} + R_з ,$$

where $R_л$ – points for work in lectures; $R_{пр}$ – points for work in practical classes; $R_{ДКР}$ – points for HCW ; $R_{МКР}$
— points for MCW ;
R_z — incentive points.

The minimum value is RC=56; the maximum value (without R_3) is RC=100. The credit

component accounts for 44% of the rating scale and equals
R3 = 44 points. Credit assessment system:

answers to all ticket tasks are missing or contain gross errors and do not meet the minimum required level of material assimilation — 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 has a starting rating $RC > 0.56R_S$, i.e. $RC \geq 56$ points, and has credited DCR and MCR.

The sum of the *RD* points scored is converted to a grade

according to the table:

Number of points	Grade
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
Conditions for admission 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 the independent performance of typical calculations of acoustic elements and modeling of acoustic paths.

Work program of the academic discipline (syllabus):
Compiled by Nelin E. A.;
Approved by the PRE Department (Minutes No. 06/2025 dated 06/24/2025)
Approved by the methodological commission of the faculty/research institute (protocol No. 06/2025 dated 25.06.2025)