Note: This is the itemized list of course descriptions for the courses I took during my bachelor's degree studies. The descriptions align with the syllabi provided by AGH University of Science and Technology but have been translated into English. For the original syllabi, please refer to AGH University Syllabi.

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Sixth semester

31. Audio Mixing Engineering
32. Live Sound Engineering
33. Methods and Software Tools in Acoustics
34. Multimedia Techniques
35. Practical Placement
36. Sound Absorption and Dispersion Technology
37. Universalism of Mathematical Modeling
38. Wireless Technologies

Seventh semester

39. Analogue Peripheral Circuits in Digital Systems
40. Digital and Microprocessor Technology
41. Dissertation Seminar in Sound in Media and Art
42. Diploma Project
43. Image Processing
44. Object-Oriented Methods of System Design
45. Practical Audio Production

Algebra

Course Code: RIAKS.Ii1P.00371.21
Field of Study: Acoustic Engineering
Faculty: Faculty of Mechanical Engineering and Robotics
Study Level: First-cycle (Bachelor's)
Study Mode: Full-time
ECTS Credits: 6
Teaching Hours: 30 Lectures, 30 Auditorium Classes
Assessment: Exam
Course Objectives
The course introduces fundamental concepts in algebra, matrix calculus, and methods for solving linear equation systems.
Learning Outcomes

- **Knowledge:**
    - Understands matrix definitions, determinants, and methods for solving linear equation systems.
    - Understands linear mappings and their relation to matrix calculus, including matrix diagonalization.
    - Knows equations of lines and planes in $\mathbb{R}^3$ and understands scalar, vector, and mixed products.
- **Skills:**
    - Proficient in matrix calculus, solving linear systems, and recognizing linear mappings.
    - Works with complex numbers and solves polynomial equations in the complex number set.

Course Content

1. **Complex Numbers (6h) –** Algebraic and trigonometric form, polynomial equations, Fundamental Theorem of Algebra.
2. **Matrices and Determinants (4h) –** Matrix types, operations, determinant properties, inverse matrices.
3. **Linear Systems (2h) –** Cramer's Rule, Rouché-Capelli theorem, Gaussian elimination.
4. **Basic Algebraic Structures (2h) –** Internal operations, groups, rings, and fields.
5. **Vector Spaces (2h) –** Basis, dimension, linear independence, subspaces.
6. **Linear Mappings & Matrix Representation (6h) –** Definitions, examples, transformation matrices.
7. **Eigenvalues and Eigenvectors (2h) –** Matrix diagonalization, characteristic equation.
8. **Analytical Geometry in $\mathbb{R}^3$ (4h) –** Equations of lines and planes, dot product, cross product, mixed product.
9. **Quadratic Forms (2h) –** Definiteness analysis of quadratic forms.

Student Workload

- **Total Hours:** 162
    - Lectures: 30h
    - Auditorium classes: 30h

    - Preparation for classes: 20h
    - Independent tasks: 80h
    - Final exam: 2h

Teaching Methods

- Lectures with discussions
- Problem-solving exercises
- Student participation and class engagement

Assessment Criteria

- **Class Activity:** Participation in discussions and exercises
- **Tests & Colloquia:** Periodic assessments during the semester
- **Final Exam:** Written exam evaluating theoretical knowledge and problem-solving skills

Prescribed Books

1. T. Jurlewicz, Z. Skoczylas, *Algebra liniowa 1. Definicje, twierdzenia, wzory.*
2. T. Jurlewicz, Z. Skoczylas, *Algebra liniowa 1. Przykłady i zadania*.

Engineering Graphics and Project Documentation

Course Code: RIAKS.Ii1O.02509.21
Field of Study: Acoustic Engineering
Faculty: Faculty of Mechanical Engineering and Robotics
Study Level: First-cycle (Bachelor's)
Study Mode: Full-time
ECTS Credits: 3
Teaching Hours: 12 Lectures, 24 Laboratory Classes
Assessment: Completion of classes
Course Objectives
Familiarization with design software and technical drawing principles for project documentation.
Learning Outcomes

- **Skills:**
    - Create orthographic and axonometric projections, views, and sections in technical drawings.
    - Apply dimensioning, tolerances, surface texture, and material specifications in technical documentation.
    - Interpret mechanical design parameters from documentation.
    - Use CAD software for 2D modeling to produce technical drawings.
    - Utilize CAD software for 3D modeling, including solid modeling, assemblies, and visualization.
- **Social Competence:**
    - Recognizes the importance of acquiring knowledge from various sources, including standards and technical catalogs.

Course Content

1. **Introduction to AutoCAD (2h) –** Basic tools, line and curve drawing.
2. **Editing Drawings (2h) –** Text insertion and modification (tolerances, fits, roughness).
3. **Dimensioning (2h) –** Creating custom dimension styles, filling closed areas in 2D.
4. **Prototype Drawings (2h) –** Creating execution drawings, preparing for printing.
5. **Introduction to 3D Graphics (2h) –** Viewing drawings in space, 3D modeling basics.
6. **Solid Modeling (2h) –** Isometric projections, rendering options.
7. **Surface and Mesh Modeling (2h) –** Edge modeling techniques.
8. **Introduction to Inventor (2h) –** 3D model creation, generating execution drawings.
9. **Advanced Inventor Features (2h) –** Assemblies, technical documentation, visualizations.
10. **Threaded Connections (2h) –** Design and documentation of bolted joints.
11. **Basic Engineering Calculations (2h) –** Computational tools in Inventor.

Student Workload

- **Total Hours:** 75
    - Lectures: 12h
    - Laboratory classes: 24h
    - Preparation for classes: 15h

    - Independent tasks: 9h
    - Project preparation: 15h

Teaching Methods

- Lectures with discussions
- Hands-on laboratory exercises
- Project work and software-based design

Assessment Criteria

- **Execution of a Project:** Technical drawings and design documentation.
- **Laboratory Performance:** Practical exercises using CAD software.
- **Tests:** Evaluation of theoretical and practical knowledge.

Prescribed Books

1. T. Dobrzański, *Rysunek Techniczny Maszynowy*, WNT, Warszawa, 2017.
2. A. Bober, M. Dudziak, *Zapis Konstrukcji*, Wydawnictwo Politechniki Poznańskiej, 1999.
3. A. Jaskulski, *Autodesk Inventor 2020PL/2020+ Podstawy metodyki projektowania*, PWN, 2019.

Optional Literature

1. I. Rydzanicz, *Zapis Konstrukcji. Podstawy*, Oficyna Wydawnicza Politechniki Wrocławskiej, 1996.
2. A. Pikoń, *AutoCAD 2019 PL. Pierwsze kroki*, Helion, 2019.

Scientific Research and Publications

- Ł. Gorazd et al., *Pomiary tłumienia wtrącenia tłumików refleksyjnych dla pobudzenia pojedynczym wybranym modem*, Postępy Akustyki, 2017.
- Ł. Gorazd et al., *Simulation of a single mode wave generation in cylindrical systems applying numerical methods*, Vibrations in Physical Systems, 2019.
- A. Snakowska et al., *Generation of a single cylindrical duct mode using a mode synthesizer*, Applied Acoustics, 2016.

Environmental Protection

Course Code: RIAKS.Ii1HS.00152.21
Field of Study: Acoustic Engineering
Faculty: Faculty of Mechanical Engineering and Robotics
Study Level: First-cycle (Engineer’s) Programme
Study Mode: Full-time
ECTS Credits: 2
Teaching Hours: 14 Lectures, 13 Laboratory Classes
Assessment: Completing the classes
Course Objectives
The course aims to provide students with fundamental knowledge about contemporary sources of environmental pollution and their impact on human health, climate, agriculture, and ecosystems. The course focuses on fostering awareness of environmental challenges and encourages sustainable practices.
Learning Outcomes
Knowledge:

- Understands the relationships between population growth, urbanization, technological progress, and the threats to the natural environment. Recognizes the importance of sustainable development.
- Recognizes the main sources and types of air, water, and soil pollution and understands their harmful effects and methods of mitigation.

Skills:

- Can identify potential environmental risks resulting from human activities and propose mitigation strategies.
- Can critically analyze the impact of various pollutants on ecosystems and human health.

Social Competences:

- Prepared to promote pro-environmental attitudes within different social environments.

Course Content

1. **Field Trip – Wastewater Treatment Plant** (W2, U1, K1)
2. **The Importance of Environmental Protection for Human Life Quality. Sustainable Development. Organization of Field Laboratories.** (W1, W2, U1, K1)
3. **Field Trip – Water Treatment Plant** (W2, U1, K1)
4. **The Water Cycle in the Atmosphere. Sources and Types of Pollution.** (W1, W2, U1, K1)
5. **Wastewater Treatment Processes.** (W1, W2, U1, K1)
6. **Field Trip – Solid Waste Disposal and Recycling Facility** (W2, U1, K1)
7. **Water Treatment Processes. Water Resources in Poland and Worldwide. Local and Global Effects of Water Deficiency and Pollution.** (W1, W2, U1, K1)
8. **Sources and Types of Air Pollution. Counteracting Air Pollution.** (W1, W2, U1, K1)
9. **Sources and Types of Solid Waste and Methods of Disposal.** (W1, W2, U1, K1)
10. **Global Warming. Energy Economy. International Efforts to Combat Environmental Pollution. Market Mechanisms for Environmental Protection.** (W1, W2, U1, K1)

Student Workload

- Total Hours: 51
  - Lectures: 14h
  - Laboratory Classes: 13h
  - Preparation for Classes: 2h
  - Independent Tasks: 8h
  - Final Test: 1h
  - Project, Report, Essay Preparation: 12h

Teaching Methods

- Lectures
- Discussion
- Group Work
- Project-based Learning
- Design Thinking
- Oxford Debate

Assessment Criteria

- **Lectures:** Active participation in class discussions.
- **Laboratory Classes:** Completion of laboratory reports and projects, including oral or written assessments of exercises.
- **Final Test:** Assessment of theoretical knowledge and understanding of pollution and environmental protection.

Prescribed Books

1. Kleczkowska B., Kleczkowski P., *Environmental Protection with Air Quality Analysis in Kraków*, AGH Publishing, 2013.
2. Kleczkowski P., *Smog in Poland – Causes, Effects, Counteractions*, PWN Scientific Publishing, 2020.
3. Popkiewicz M., Kardaś A., Malinowski S., *Science of Climate*, Sonia Draga Publishing, 2019.

Additional Information

The course emphasizes hands-on experience through field trips to environmental treatment facilities and encourages students to engage in project-based learning. Students will be evaluated based on their participation, projects, reports, and final test performance.

Mathematical Analysis 1

Course Code: RIAKS.Ii1MA.00147.21
Field of Study: Acoustic Engineering
Faculty: Faculty of Mechanical Engineering and Robotics
Study Level: First-cycle (Bachelor's)
Study Mode: Full-time
ECTS Credits: 5
Teaching Hours: 30 Lectures, 60 Independent Study
Assessment: Examination

Course Objectives

- To introduce students to the fundamentals of mathematical analysis, including limits, continuity, differentiation, and integration.
- To develop problem-solving skills in engineering contexts, especially for acoustics-related applications.

Learning Outcomes

- **Knowledge**:
  - Understand the basic concepts of mathematical analysis (limits, continuity, derivatives, integrals).
  - Grasp the role of mathematical analysis in solving engineering problems.
- **Skills**:
  - Apply differentiation and integration techniques to solve engineering problems.
  - Analyze the behavior of functions, including power series and their convergence.
- **Social Competence**:
  - Appreciate the importance of continual learning and application of mathematical analysis in engineering practice.

Course Content

1. **Introduction to Mathematical Analysis** (2h)
   - Real numbers, sequences, and series of numbers.
   - Limit of sequences, convergence criteria.
2. **Continuity** (4h)
   - Continuity of functions.
   - Intermediate value theorem, extreme value theorem.
   - Uniform continuity and its applications.
3. **Differentiation** (6h)
   - Definition of derivatives.
   - Mean value theorem, Taylor's theorem, L'Hopital's rule.
4. **Integration** (8h)
   - Riemann integral.
   - Fundamental theorem of calculus, integration techniques: substitution, by parts.

5. **Series of Functions** (4h)
   - Pointwise and uniform convergence of series.
   - Power series and convergence criteria.
6. **Applications** (6h)
   - Engineering applications of differentiation and integration (optimization, area calculations, etc.).
   - Use of series for solving practical problems in acoustics.

Student Workload

- **Total Hours**: 90
  - Lectures: 30h
  - Independent Study: 60h
  - Preparation for Classes: 30h
  - Final Exam: 1h

Teaching Methods

- **Lectures**: Theoretical content with practical examples.
- **Exercises**: Problem-solving sessions to apply concepts to engineering problems.
- **Case Studies**: Application of mathematical analysis in real-world acoustics scenarios.

Assessment Criteria

- **Examination**: Assessment of theoretical and practical knowledge through an end-of-semester exam.
- **Class Participation**: Active involvement in exercises and discussions during lectures.

Prescribed Books

Obligatory:

1. W. Rudin, *Principles of Mathematical Analysis*, McGraw-Hill, 1976.
2. T. D. Kaczmarek, *Mathematical Analysis*, Wydawnictwo PWN, 2020.
3. S. Axler, *Linear Algebra Done Right*, Springer, 2015.

Optional Literature:

1. J. Stewart, *Calculus: Early Transcendentals*, Cengage Learning, 2015.
2. P. V. O'Neil, *Advanced Engineering Mathematics*, Cengage Learning, 2018.

Scientific Research and Publications

- Pałosz, J., & Kowalski, P., *Applications of Mathematical Analysis in Acoustics*, Journal of Acoustical Science, 2019.
- Kowalski, P., & Ławniczak, M., *Numerical Methods for Acoustic Engineering Problems*, Computational Acoustics, 2018.
- Pałosz, J., & Dobrzyński, K., *Integration Methods for Complex Acoustic Systems*, Journal of Engineering Mathematics, 2020.

Programming Methods and Techniques

Course Code: RIAKS.Ii1K.02499.21
Field of Study: Acoustic Engineering
Faculty: Faculty of Mechanical Engineering and Robotics
Study Level: First-cycle (Engineer) Programme
Study Mode: Full-time
Profile: General Academic
Didactic Cycle: 2021/2022
Lecture Languages: Polish
Mandatoriness: Obligatory
Block: Core Modules
Course Related to Scientific Research: No
Course Coordinator: Marek Frankowski
Lecturers: Marek Frankowski, Sławomir Ziętek
Period: Semester 1
Assessment Method: Completing the classes
ECTS Credits: 8
Teaching Hours: 28 Lectures, 56 Laboratory Classes

Course Objectives
This course focuses on fundamental programming concepts and techniques. Students will learn to apply key algorithms, work with data structures, and program in C# and Python. The goal is to develop problem-solving skills using programming tools, with a focus on object-oriented programming, system-level programming, and parallel computing.

Learning Outcomes
Knowledge:
- **W1** Has knowledge of basic algorithms and data structures.

Skills:
- **U1** Can program in C# and Python, adhering to correct syntax and data structures.
- **U2** Can represent problems as computer programs by constructing correct modules.

Social Competences:
- **K1** Is able to present programming topics effectively.

Student Workload
- **Total Hours:** 240
    - Lectures: 28h
    - Laboratory Classes: 56h
    - Preparation for Classes: 28h
    - Independent Tasks: 28h
    - Project, Presentation, Essay, Report: 100h

Workload Involving Teacher:

- **Hours:** 84

Course Content

1. **Introduction to Course, Number Systems, Computer Arithmetic, Programming Paradigms, Basic Programming, Variables, Control Statements**
   Overview of programming essentials and various programming paradigms.
2. **Linux Operating System, Console, Graphical vs Text Mode, Functions**
   Introduction to using Linux for programming tasks.
3. **Object-Oriented Programming, Classes and Methods, File Organization, Best Practices, Code Formatting, Regular Expressions, grep, pipe**
   Emphasis on object-oriented programming concepts and tools in Linux.
4. **Access Modifiers, Get and Set, Constructors, Compilation vs Interpretation, Basics of Python**
   Fundamentals of C# and Python, focusing on their structure and features.
5. **Arrays, Lists, Dictionaries, File Handling, Exceptions, Selected Libraries**
   Using data structures and managing exceptions in Python and C#.
6. **Sorting and Searching Algorithms, Computational Complexity, Problem Classification, Numerical Stability**
   Exploring algorithms for efficiency and problem-solving strategies.
7. **Trees and Graphs, Selected Graph Algorithms**
   Advanced algorithms related to tree and graph structures.
8. **Parallel Programming, fork, The Five Philosophers Problem, Amdahl's Law**
   Introduction to parallel programming concepts and challenges.
9. **Contemporary Issues in Computer Science**
   Addressing current trends and issues in the field.

Teaching Methods

- Lectures
- Discussions
- Oxford-style debates
- Hands-on laboratory exercises

Assessment Criteria

- **Class Activity:** Participation and demonstration of skills in laboratory exercises and presentations
- **Tests:** Written or oral tests evaluating understanding of course content
- **Project:** Completion of a programming project that demonstrates problem-solving and coding ability

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Literature, Online Resources:

- C#: C# Documentation
- Python: Python Beginners Guide, Python Book
- C#: C# Book
- HTML5: HTML5 Book
- LaTeX: LaTeX Book

Protection of Intellectual Property

Course Code: RIAKS.Ii1HS.00147.21
Field of Study: Acoustic Engineering
Faculty: Faculty of Mechanical Engineering and Robotics
Study Level: First-cycle (Engineer's) Programme
Study Mode: Full-time Studies
Profile: General Academic
Lecture Languages: Polish
Course Coordinator: Jerzy Pałosz
Period: Semester 1
Examination: Yes

Course Objectives

- To introduce students to key concepts in intellectual property protection, focusing on copyright and industrial property laws relevant to acoustics and music.
- To develop skills for identifying legal issues and applying appropriate laws for IP management.
- To raise awareness about the evolving nature of IP law and its impact on entrepreneurship.

Learning Outcomes

- **Knowledge**: Understand the basics of intellectual property protection, including laws on copyright and industrial property.
- **Skills**: Be able to define legal situations and apply relevant legal provisions from reliable sources.
- **Social Competence**: Recognize the importance of staying updated with IP law changes and use IP knowledge effectively in business contexts.

Course Content

1. **Introduction to Intellectual Property**
    - Overview of intangible assets, public and private domains, and the evolution of IP protection.
    - Difference between copyright and industrial property protection.
2. **Copyright Protection**

    - Defining works, particularly in the context of music and computer-generated works.
    - Duration and scope of copyright protection.
3. **The Creator and Authorship**
    - Issues related to authorship, anonymous works, and works created in employment.
4. **Copyright Rights**
    - Understanding moral rights and economic rights under copyright law.
    - Limitations such as fair use, personal use, and public performance.
5. **Industrial Property Law and Patents**
    - Criteria for patentability: novelty, inventive step, industrial applicability.
    - Non-patentable inventions and exclusions.
6. **Patent Applications and Licenses**
    - Basic procedures for patent applications and licensing types (open, compulsory).
7. **Protection of Related Rights**
    - Rights related to performances, phonograms, and audiovisual works.
8. **European Patent and Industrial Design**
    - Legal process for European patents and industrial design protection.

Student Workload

- **Total Hours**: 75
    - Lectures: 28h
    - Independent Tasks: 46h
    - Examination: 1h

Teaching Methods

- **Lectures**: Key concepts of intellectual property protection and law.
- **E-learning**: Supplementary online resources.
- **Case Study**: Real-world examples and legal precedents.

Assessment

- **Examination**: A test of theoretical and practical knowledge.

Recommended Literature

Obligatory:

1. *Krótki kurs własności intelektualnej. Materiały dla uczelni*. prawokultury.pl/kurs.
   Optional:
2. J. Barta, R. Markiewicz, *Prawo autorskie*, 2016.
3. T. Szymanek, *Prawo własności przemysłowej. Podręcznik akademicki*, 2008.
4. P. Piesiewicz, *Utwór muzyczny i jego twórca*, 2009.

Workplace Safety and Ergonomics

Course Code: RIAKS.Ii1HS.00619.21
Field of Study: Acoustic Engineering
Faculty: Faculty of Mechanical Engineering and Robotics
Study Level: First-cycle (Engineer's) Programme
Study Mode: Full-time Studies
Profile: General Academic
Lecture Languages: Polish
Course Coordinator: Cezary Kasprzak
Period: Semester 1
Examination: Yes

Course Objectives

- To familiarize students with ergonomic and safety principles in the workplace, emphasizing adapting work elements to human capabilities and environmental conditions.
- To raise awareness of the physical and mental effort required for maintaining optimal performance in various work environments.

Learning Outcomes

- **Knowledge**: Understand key concepts related to ergonomics and workplace safety.
- **Skills**: Integrate ergonomics into engineering tasks, using a system-based approach, while considering both technical and non-technical factors.
- **Social Competence**: Collaborate effectively in teams, prepare detailed reports, and solve ergonomic problems collectively.

Course Content

1. **Introduction to Ergonomics**
    - History, definition, scope, and goals of ergonomics.
    - Basic ergonomic model and job evaluation methods.
    - Human physiology (fatigue, thermoregulation) and its impact on work efficiency.
    - The importance of posture, workspace design, and environmental conditions.
2. **Anthropometry and Workstation Design**

- Measuring and analyzing anthropometric data for workstation design.
- Evaluating ergonomic features of office environments (e.g., computer workstations).
- Addressing physical workload, monotony, and fatigue.
- Examining lighting, acoustics, and vibration in work environments.

Student Workload

- **Total Hours**: 54
  - Lectures: 12h
  - Laboratory Classes: 12h
  - Preparation for Classes: 15h
  - Project/Report: 15h

Teaching Methods

- **Lectures**: Key concepts and theories of ergonomics and workplace safety.
- **Laboratory Classes**: Hands-on exercises and project-based learning.
- **E-learning**: Supplementary online resources.
- **Group Work**: Collaborative assignments and problem-solving.

Assessment

- **Laboratory Work**: Test, report, and group project.
- **Lectures**: Participation, exercises, and teamwork.

Recommended Literature

Obligatory:

1. M. Wykowska, *Ergonomia*, AGH, Kraków, 1994.
2. M. Wykowska, *Zajęcia laboratoryjne z ergonomii*, AGH, 1995.
3. D. Koradecka (ed.), *Bezpieczeństwo pracy i ergonomia*, CIOP, 1997.

Optional:

1. M. Kamieńska-Żyła, *Stanowisko komputerowe*, AGH, Kraków, 1995.

Electrical Engineering and Circuit Theory

Basic Information
Field of Study: Acoustic Engineering
Major: -
Organisational Unit: Faculty of Mechanical Engineering and Robotics
Study Level: First-cycle (engineer) programme
Form of Study: Full-time studies
Profile: General academic
Didactic Cycle: 2021/2022
Course Code: RIAKS.Ii2O.02508.21
Lecture Languages: Polish
Mandatoriness: Obligatory
Block: General Modules
Course Related to Scientific Research: Yes
Course Coordinator: Wiesław Wszołek
Lecturer: Wiesław Wszołek, Tadeusz Wszołek
Period: Semester 2
Method of Verification of Learning Outcomes: Completing the classes
Activities and Hours:

- **Lectures**: 20
- **Auditorium Classes**: 28
Number of ECTS Credits: 4

Course's Learning Outcomes

- **Knowledge**
    - W1: Understands linear electrical circuits, their two-port and four-port elements, and basic circuit properties (IAK1A_W14).
    - W2: Knowledge of mathematical methods used in DC, sinusoidal AC, and non-sinusoidal periodic current circuit analysis, and transient states in time and complex frequency domains (IAK1A_W14).
- **Skills**
    - U1: Can model and analyze simple electrical circuits, selecting appropriate methods and justifying the choices (IAK1A_U04, IAK1A_U07).
    - U2: Can solve steady-state circuits (DC and sinusoidal), calculate unsteady states, and analyze currents, voltages, and powers in symmetrical and asymmetrical three-phase systems (IAK1A_U04, IAK1A_U07).

Student Workload

- **Lectures**: 20 hours
- **Auditorium Classes**: 28 hours
- **Preparation for Classes**: 30 hours
- **Independent Tasks**: 30 hours
  Total Student Workload: 108 hours
  Workload Involving Teacher: 48 hours

Program Content

1. **Introduction to Circuit Theory**: Basic electrical circuit concepts, equivalent circuit elements, and methods for calculating simple circuits with a single source.
2. **Mathematical Methods**: Classical methods, superposition, loop current method, node voltage method.
3. **AC Circuits**: Sinusoidal current circuits, operator method for sinusoidal excitation, power calculations, resonance phenomena.
4. **Three-phase Circuits**: Symmetrical and asymmetrical systems, voltage and current calculations, power in three-phase circuits.
5. **Unsteady-State Analysis**: Differential equations for first and second-order circuits, Laplace transforms, and operator calculus for circuit analysis.
6. **Periodic Non-sinusoidal Circuits**: Distorted waveforms, harmonic analysis, power analysis in non-sinusoidal circuits.
7. **Four-pole Elements**: Analysis of four-pole elements and reactive filters.

Teaching Methods and Techniques

- **Lectures**
- **Activities**:
  - Lectures: Test
  - Auditorium Classes: Test

Rules of Participation

- **Lectures**: Active participation in lectures, asking questions and clarifying doubts. Audio-visual recording of the lecture requires instructor consent.
- **Auditorium Classes**: Students must prepare for exercises as specified by the instructor (e.g., through problem sets). Performance assessment may be oral or written, affecting the final grade. All laboratory exercises must be completed for module credit.

Literature

- **Obligatory**:

1. S. Bolkowski: *Teoria obwodów elektrycznych*, WNT, 1995.
2. J. Osiowski, J. Szabatin: *Podstawy teorii obwodów* Vol. I-III, WNT, 1993-1998.
3. S. Bolkowski et al.: *Teoria obwodów elektrycznych: zadania*, WNT, 1998.
4. J. Szabatin & E. Śliwa: *Zbiór zadań z teorii obwodów* Vol. I & II, Polit. Warszawska, 1997.

- **Optional**:
  1. Vademecum Elektryka, COSiW, 2003.
  2. Z. Majerowska: *Elektrotechnika Ogólna w Zadaniach*, PWN, 1999.
  3. S. Mitkowski: *Nieliniowe obwody elektryczne*, AGH, 1999.

Scientific Research and Publications

- **Research**:
  - Investigation of frequency characteristics of measurement microphones and loudspeakers.
  - Calibration of acoustic measurement instruments.
- **Publications**:

1. R. Tadeusiewicz, T. Wszołek, A. Izworski, W. Wszołek: *Recognition and Diagnosing of The Technical Condition of An UHV Transmission Line Using The Acoustic Signal of The Corona Process*, Inter-Noise 99, Florida.

2. R. Tadeusiewicz et al.: *Recognition of Defects in High Voltage Transmission Lines Using Acoustic Signals*, IEEE Workshop, Sydney.

3. T. Wszołek et al.: *Investigations of Corona-induced Vibration on High Voltage Conductors*, Inter Noise 2000, France.

Fundamentals of Probability and Statistics

Basic Information

- **Field of Study**: Acoustic Engineering
- **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
- **Study Level**: First-cycle (Engineer) Program
- **Form of Study**: Full-time Studies
- **Profile**: General Academic
- **Didactic Cycle**: 2021/2022
- **Course Code**: RIAKS.Ii2P.02526.21
- **Lecture Languages**: Polish
- **Mandatoriness**: Obligatory
- **Block**: Foundation Modules
- **Course Related to Scientific Research**: Yes
- **Course Coordinator**: Janusz Zalewski
- **Lecturers**: Janusz Zalewski, Aleksandra Król-Nowak
- **Period**: Semester 2

Activities and Hours

- **Lectures**: 28
- **Auditorium Classes**: 28
- **Number of ECTS Credits**: 4

Course Goals

- **C1**: Introduce basic probability theory and mathematical statistics.
- **C2**: Provide foundational knowledge for the course *Statistics for Acousticians*.
- **C3**: Highlight the significance of statistics across disciplines.
- **C4**: Familiarize students with the ethics of statistical analysis.

Learning Outcomes

- **Knowledge**:
  - W1: Concepts of random events and probability, basic probability models.
  - W2: Random variable, one-dimensional probability distributions and their parameters.
  - W3: Independence of random variables, limit theorems, basic statistical concepts.
  - W4: Measurement uncertainty.
- **Skills**:
  - U1: Solve practical problems using combinatorics and probability theory, investigate random variable independence.
  - U2: Apply mathematical statistics to analyze acoustical engineering data.
  - U3: Use R programming for statistical data analysis.
- **Social Competences**:
  - K1: Analytical thinking, independent data synthesis, effective teamwork.
  - K2: Conduct and verify data analysis with awareness of professional ethics.

Student Workload

- **Lectures**: 28 hours
- **Auditorium Classes**: 28 hours
- **Preparation for Classes**: 28 hours
- **Independent Tasks**: 28 hours
- **Final Test/Colloquium**: 2 hours
- **Total Student Workload**: 114 hours
- **Workload Involving Teacher**: 56 hours

Program Content

1. **Probability spaces**, classical and axiomatic definitions, probability properties.
2. **Classical schemes**, geometric probability, conditional probability, Bayes' theorem.
3. **Independence of events**, Cartesian product, Bernoulli schemes.
4. **Probability distributions**: discrete and continuous, cumulative distribution function.

5. **Random variables and vectors**, marginal and conditional distributions, independence.
6. **Distribution parameters**: expected value, variance, standard deviation, moments, quantiles.
7. **Key distributions**: Bernoulli, binomial, Poisson, exponential, normal, t-student, chi-square.
8. **Normal distribution properties**, central limit theorem.
9. **Statistical model**: unbiased and consistent estimators, maximum likelihood estimation.
10. **Interval estimation**.
11. **Hypothesis testing**, parametric tests for one population.

Teaching Methods
Lectures, E-learning, Group Work, Peer Assessment

Literature

- **Obligatory**:
  - W. Krysicki, J. Bartos, "Rachunek prawdopodobieństwa i statystyka matematyczna w zadaniach część 1", Państwowe Wydawnictwo Naukowe
  - J. Jakubowski, R. Sztencel, "Rachunek prawdopodobieństwa dla (prawie) każdego", Wydawnictwo SCRIPT
- **Optional**:
  - A. Plucińska, E. Pluciński, "Probabilistyka. Procesy stochastyczne. Statystyka matematyczna. Rachunek prawdopodobieństwa", Wydawnictwo WNT

Scientific Research & Publications

- **Research**:
  - Multi-channel sound reproduction and analysis of direct and reflected sounds.
- **Publications**:
  - Kleczkowski P., Król A., Małecki P., "Multichannel Sound Reproduction Quality Improves with Angular Separation of Direct and Reflected Sounds", Journal of the Audio Engineering Society.

High-Level Programming Languages

Basic Information

- **Field of Study**: Acoustic Engineering
- **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
- **Study Level**: First-cycle (Engineer) Program
- **Form of Study**: Full-time Studies
- **Profile**: General Academic
- **Didactic Cycle**: 2021/2022
- **Course Code**: RIAKS.Ii2K.02510.21
- **Lecture Languages**: Polish
- **Mandatoriness**: Obligatory
- **Block**: Core Modules
- **Course Coordinator**: Marek Frankowski
- **Lecturer**: Marek Frankowski
- **Period**: Semester 2

Activities and Hours

- **Lectures**: 28
- **Laboratory Classes**: 28
- **Number of ECTS Credits**: 4

Course Goals

- Introduce programming best practices, design patterns, and object-oriented paradigms.
- Equip students with proficiency in C++, Python, and scripting languages.
- Develop teamwork and problem-solving skills through collaborative projects.

Learning Outcomes

- **Knowledge**:
    - W1: Knowledge of design patterns and software modeling.

- **Skills**:
  - U1: Proficiency in C++ (including new standards).
  - U2: Proficiency in Python and scripting languages.
- **Social Competences**:
  - K1: Ability to work effectively in a programming team.

Student Workload

- **Lectures**: 28 hours
- **Laboratory Classes**: 28 hours
- **Preparation for Classes**: 21 hours
- **Independent Tasks**: 35 hours
- **Final Exam**: 2 hours
- **Total Student Workload**: 114 hours
- **Workload Involving Teacher**: 56 hours

Program Content

1. **Programming Best Practices**: Naming conventions, code formatting, object-oriented paradigms.
2. **Unified Modeling Language (UML)**: Use case diagrams, sequence diagrams, Microsoft Visio, Visual Paradigm.
3. **Object-Oriented Design**: Class diagrams, associations, inheritance, composition over inheritance.
4. **Design Patterns**: Creational, structural, and behavioral patterns.
5. **Software for Enterprise and Game Development**: Challenges of modern enterprise applications and game development (text adventure, AI, turn-based vs. real-time games).
6. **Overview of High-Level Programming Languages**: Comparison of languages, focusing on C#.

Teaching Methods
Lectures, Project-based learning, Oxford debate, Socratic questioning

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Literature

- **Obligatory**:
    - Gamma et al., "Design Patterns: Elements of Reusable Object-Oriented Software", Helion, 2017
    - Freeman et al., "Head First Design Patterns", Helion, 2010
    - Russ, M., "UML 2.0: Introduction", Helion, 2007

Mathematical Analysis 2

Basic Information

- **Field of Study**: Acoustic Engineering
- **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
- **Study Level**: First-cycle (Engineer) Program
- **Form of Study**: Full-time Studies
- **Profile**: General Academic
- **Didactic Cycle**: 2021/2022
- **Course Code**: RIAKS.Ii2P.02263.21
- **Lecture Languages**: Polish
- **Mandatoriness**: Obligatory
- **Block**: Foundation Modules
- **Course Coordinator**: Andrzej Żak
- **Lecturer**: Andrzej Żak
- **Period**: Semester 2

Activities and Hours

- **Lectures**: 30
- **Auditorium Classes**: 30
- **Number of ECTS Credits**: 6

Course Goals

- Deepen knowledge of differential and integral calculus in multivariable functions.
- Apply mathematical concepts such as partial derivatives, multiple integrals, and differential equations to real-world problems.
- Prepare students to solve advanced optimization and physics-related problems using mathematical methods.

Learning Outcomes

- **Knowledge**:
  - W1: Knowledge of differential and integral calculus for multivariable functions.
  - W2: Knowledge of integral calculus for multivariable functions.
  - W3: Basic knowledge of differential equations, Fourier series, and integral transforms.
- **Skills**:
  - U1: Ability to apply multivariable calculus in optimization problems.
  - U2: Ability to apply multiple, line, and surface integrals in physical and geometric problems.
  - U3: Ability to solve basic differential equations (including using Laplace transforms).
  - U4: Ability to expand functions in Fourier series.
- **Social Competences**:
  - K1: Understanding the civilizational significance of mathematics and its applications.
  - K2: Ability to formulate precise questions to deepen understanding.

Student Workload

- **Lectures**: 30 hours
- **Auditorium Classes**: 30 hours
- **Preparation for Classes**: 30 hours
- **Independent Tasks**: 60 hours
- **Final Exam**: 2 hours
- **Total Student Workload**: 152 hours
- **Workload Involving Teacher**: 60 hours

Program Content

1. **Limits of Sequences and Functions**: Real functions of several variables, limits, and continuity.
2. **Partial and Directional Derivatives**: Differentiability, gradients, higher-order derivatives, and Taylor's formula.

3. **Applications of Derivatives**: Local and global extrema, constrained extrema, and optimization.
4. **Multiple Integrals**: Double and triple integrals, change of variables, geometric and physical applications.
5. **Line and Surface Integrals**: Green’s Theorem, Gauss’s Theorem.
6. **Laplace Transform**: Overview, basic properties, and essential transforms.
7. **Differential Equations**: Separable and linear first-order equations, linear equations with constant coefficients, and Laplace transforms.
8. **Fourier Series**: Fourier expansions and transformations.

Teaching Methods
Lectures, Discussions

Literature

- **Obligatory**:
    - Żakowski, W., Kołodziej, W., *Matematyka cz. 2*, WNT, 1974
    - Żakowski, W., Leksiński, W., *Matematyka cz. 4*, WNT, 1995
    - Fichtenholz, G. M., *Rachunek różniczkowy i całkowy*, PWN, 1999
    - Krysicki, W., Włodarski, L., *Analiza matematyczna w zadaniach*, PWN, 1993
    - Stankiewicz, W., *Zadania z matematyki dla wyższych uczelni technicznych*, PWN, 2001

Mechanics

Basic Information

- **Field of Study**: Acoustic Engineering
- **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
- **Study Level**: First-cycle (Engineer) Program
- **Form of Study**: Full-time Studies
- **Profile**: General Academic
- **Didactic Cycle**: 2021/2022
- **Course Code**: RIAKS.Ii2O.00098.21
- **Lecture Languages**: Polish
- **Mandatoriness**: Obligatory
- **Block**: General Modules
- **Course Coordinator**: Leszek Majkut
- **Lecturer**: Leszek Majkut, Ryszard Olszewski
- **Period**: Semester 2

Activities and Hours

- **Lectures**: 28
- **Auditorium Classes**: 28
- **Number of ECTS Credits**: 6

Course Goals

- Provide fundamental knowledge of statics, kinematics, and dynamics of mechanical systems.
- Develop the ability to analyze static equilibrium, motion equations, and apply Newton's laws of motion in real-world mechanical problems.
- Understand key concepts such as force systems, work, energy, momentum, and their conservation.

Learning Outcomes

- **Knowledge**:
    - W1: Understanding the basic concepts of statics, including equilibrium of force systems and rigid bodies.
    - W2: Knowledge of kinematics of material points and rigid bodies, methods to calculate velocities and accelerations in linear and compound motions.
    - W3: Understanding dynamics of material points and rigid bodies, including power, work, kinetic and potential energy, and conservation laws.
- **Skills**:
    - U1: Ability to determine static reactions in planar and spatial systems, including systems with friction.
    - U2: Ability to analyze velocities and accelerations of points on rigid bodies in translational, rotational, and planar motion.
    - U3: Ability to apply Newton's laws of motion to build models for simple mechanical systems.

Student Workload

- **Lectures**: 28 hours
- **Auditorium Classes**: 28 hours
- **Preparation for Classes**: 37 hours
- **Independent Tasks**: 52 hours
- **Contact Hours**: 5
- **Total Student Workload**: 150 hours
- **Workload Involving Teacher**: 56 hours

Program Content

1. **Statics**: Basic concepts, classification of forces, constraints, reaction forces, resultant forces, moment of force about a point and an axis, force couples, central, arbitrary planar and spatial systems, reduction and equilibrium, friction.
   Kinematics of Points and Rigid Bodies: Equations of motion, velocity, and acceleration in linear and compound motions.
   Dynamics: Newton's laws, free and constrained motion of a material point, dynamic equations of motion, center of mass, d'Alembert's principle, momentum, impulse, torque. Energy, work, power, efficiency, and conservation of energy.
   Dynamics of Rigid Bodies: Translational, rotational, and planar motion equations of rigid bodies.

2. **Statistical Reactions**: Calculation and analysis in planar and spatial systems. Application of frictional forces.
   Kinematics of Bodies: Analysis of velocities and accelerations in various motions.
   Newtonian Dynamics: Application of Newton's principles in building models for simple mechanical systems. Energy and conservation principles.

Teaching Methods
Lectures

Literature

- **Obligatory**:

    - Engel, Z., Giergiel, J., *Statyka*, Wydawnictwa AGH, Kraków, 2000
    - Engel, Z., Giergiel, J., *Kinematyka*, Wydawnictwa AGH, Kraków, 2000
    - Engel, Z., Giergiel, J., *Dynamika*, Wydawnictwa AGH, Kraków, 2000
    - Knudsen, J.M., Hjorth, P.G., *Elements of Newtonian Mechanics*, Springer-Verlag, 2000
    - Giergiel, J., Głuch, L., Łopata, A., *Zbiór zadań z mechaniki. Metodyka rozwiązań*, Uczelniane Wydawnictwa Naukowo-Dydaktyczne AGH, Kraków, 2001
    - Nizioł, J., *Metodyka rozwiązywania zadań z mechaniki*, WNT, Warszawa, 2002
    - Mieszczerski, I., *Zbiór zadań z mechaniki*, PWN, Warszawa, 1971

Physics

Basic Information
• **Field of Study:** Acoustic Engineering
• **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
• **Study Level:** First-cycle (Engineer) Programme
• **Form of Study:** Full-time Studies
• **Profile:** General Academic
• **Didactic Cycle:** 2021/2022
• **Course Code:** RIAKS.Ii2P.00920.21
• **Lecture Languages:** Polish
• **Mandatoriness:** Obligatory
• **Block:** Foundation Modules
• **Course Related to Scientific Research:** No
• **Course Coordinator:** Tomasz Stapiński
• **Lecturer:** Tomasz Stapiński
• **Period:** Semester 2

Activities and Hours
• **Lectures:** 30
• **Auditorium Classes:** 15
• **Laboratory Classes:** 15
• **Number of ECTS Credits:** 6

Course Goals
• C1: Introduce students to the fundamentals of physics and the ability to describe physical phenomena using basic laws and principles.

Learning Outcomes

Knowledge:
• **W1:** Understands the significance of physics as a natural science, its role in modern science and technology, and the interplay between theory and experiment.
• **W2:** Possesses up-to-date knowledge of physical phenomena and fundamental natural interactions.
• **W3:** Has foundational knowledge in mechanics, thermodynamics, electricity, magnetism, and elements of modern physics—crucial for understanding phenomena in electronic components, transmission systems, and telecommunications.
• **W4:** Acquires the mathematical basis for describing physical phenomena, with examples of applying vector, differential, and integral calculus in physics.

Skills:
• **U1:** Can apply appropriate physical laws and principles to solve problems in dynamics, vibrations, wave motion, electromagnetism, thermodynamics, and optics.
• **U2:** Acquires mathematical tools for describing physical phenomena, with practical examples from vector, differential, and integral calculus.
• **U3:** Independently solves problems in classical mechanics, estimates task duration, and applies physical laws to issues in vibrations, wave motion, electromagnetism, thermodynamics, and optics.
• **U4:** Uses suitable physical principles to solve a range of problems in dynamics, vibrations, and related areas.

Social Competences:
• **K1:** Recognizes the need for continuous self-education and the importance of mathematical tools in describing physical phenomena.
• **K2:** Understands the non-technical aspects and environmental impact of engineering activities, acknowledging the responsibility inherent in decision-making.

Student Workload
• **Lectures:** 30 hours
• **Auditorium Classes:** 15 hours
• **Laboratory Classes:** 15 hours
• **Preparation for Classes:** 30 hours
• **Independent Tasks:** 20 hours
• **Project/Presentation/Report Preparation:** 40 hours
• **Total Student Workload:** 150 hours
• **Workload Involving Teacher:** 60 hours

Program Content

1. **Describing Physical Reality:**
   • Develop the ability to describe physical phenomena using basic laws and principles.
   • Solve simple computational problems and prepare for more complex technical challenges.
   (Learning Outcomes: W1, W2, W3, W4, U3, K1, K2; Activities: Lectures)

2. **Auditorium Exercises:**
   • Reinforce lecture content by solving problems related to fundamental physics.
   • Engage in discussions and complete homework assignments to consolidate understanding.
   (Learning Outcomes: W3, W4; Activities: Auditorium Classes)

3. **Laboratory Experiments:**
   • Gain hands-on experience by planning and conducting experiments, measuring physical quantities, and analyzing uncertainties.

• Prepare reports based on experimental findings.
(Learning Outcomes: W2, W3, U1, U2, U3, U4, K1, K2; Activities: Laboratory Classes)

Teaching Methods
Lectures

Literature
• **Obligatory:**

1. D. Halliday, R. Resnick, J. Walker, *Podstawy Fizyki* (Vols. 1–5), PWN Warszawa, 2003
2. C. Kittel, *Wstęp do Fizyki Ciała Stałego*, PWN Warszawa, 1975
3. E.M. Purcel, *Elektryczność i Magnetyzm*, PWN Warszawa, 1973
4. R. Eisberg, R. Resnick, *Fizyka Kwantowa*, PWN Warszawa, 1983

Fundamentals of Acoustics

Basic Information

• **Field of Study:** Acoustic Engineering
• **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
• **Study Level:** First-cycle (Engineer) Programme
• **Form of Study:** Full-time Studies
• **Profile:** General Academic
• **Didactic Cycle:** 2021/2022
• **Course Code:** RIAKS.Ii4K.02500.21
• **Lecture Languages:** Polish
• **Mandatoriness:** Obligatory
• **Block:** Core Modules
• **Course Related to Scientific Research:** Yes
• **Course Coordinator:** Jerzy Wiciak
• **Lecturers:** Jerzy Wiciak, Adam Pilch, Łukasz Gorazd
• **Period:** Semester 3
• **Method of Verification of Learning Outcomes:** Exam

Activities and Hours

• **Lectures:** 42
• **Auditorium Classes:** 26
• **Laboratory Classes:** 14
• **Number of ECTS Credits:** 8

Course's Learning Outcomes

Knowledge:

• **W1:** Possesses general knowledge of the fundamentals of acoustics.
• **W2:** Understands the concepts related to the acoustic field and its modeling.
• **W3:** Has basic knowledge of noise sources and their impact on the environment.

Skills:

• **U1:** Can recognize the interdisciplinary nature of acoustics, defines and differentiates basic acoustic field parameters, and utilizes simulation methods to model and analyze the acoustic field.
• **U2:** Can assess the harmful effects of various noise sources on humans and the environment.

Social Competences:

• **K1:** Understands the interdisciplinary nature of acoustic engineering and is capable of collaborating with specialists from other engineering fields, musicians, and sound engineers.

Student Workload
• **Lectures:** 42 hours
• **Auditorium Classes:** 26 hours
• **Laboratory Classes:** 14 hours
• **Preparation for Classes:** 90 hours
• **Realization of Independently Performed Tasks:** 30 hours
• **Examination or Final Test/Colloquium:** 2 hours

• **Total Student Workload:** 204 hours
• **Workload Involving Teacher:** 82 hours

Program Content

1. **Basic Acoustic Parameters:**
   • Sound pressure, sound intensity, sound power, and sound pressure level.
   • Plane wave characteristics: wavelength, frequency, amplitude.
   (Learning Outcomes: W1, W2, W3, U1, U2, K1; Activities: Auditorium Classes)

2. **Wave Phenomena:**
   • Sound wave propagation in open space, interference, diffraction, and refraction.
   • Superposition of waves and sound sources, including monopoles, dipoles, and interference patterns.
   (Learning Outcomes: W1, W2, W3, U1, U2, K1; Activities: Lectures)

3. **Acoustic Field in Laboratory Settings:**
   • Measurement of sound pressure and intensity, wave interference, and resonance studies.
   • Sound speed in different mediums and the directivity of sound sources.
   (Learning Outcomes: W1, W2, W3, U1, U2, K1; Activities: Laboratory Classes)

Teaching Methods
Lectures

Methods of Verification
• **Lectures:** Activity during classes, test, examination
• **Auditorium Classes:** Activity during classes, execution of exercises, test
• **Laboratory Classes:** Activity during classes, execution of laboratory experiments, test

Credit Conditions:
• **Lecture:** Passing tests
• **Exercises:** Completing two tests covering class material, active participation
• **Laboratories:** Positive results from tests, passing reports on conducted experiments

Conditions for Admission to the Exam:
• Positive evaluations in lectures, exercises, and laboratories

Literature

• Obligatory:

1. A. Dobrucki, *Podstawy Akustyki*, Wydawnictwo Politechniki Wrocławskiej, 1987
2. Z. Engel, R. Panuszka, *Podstawy Akustyki*, Wydawnictwo AGH, 1989
3. F. A. Everest, *Podręcznik Akustyki*, Wydawnictwo SONIA DRAGA
4. R. Makarewicz, *Dźwięki i Fale*, Wydawnictwo Naukowe UAM, 2017
5. I. Malecki, *Teoria Fal i Układów Akustycznych*, PWN
6. M. Kwiek, *Akustyka Laboratoryjna Cz. I Podstawy Akustyki Teoretycznej*, PWN
7. B.C.J. Moore, *Wprowadzenie do Psychologii Słyszenia*, PWN, 1999

• Optional:

1. H. Kuttruff, *Acoustics: An Introduction*, Taylor & Francis, 2007
2. T.D. Rossing, *Springer Handbook of Acoustics*, Science+Business Media, 2007
3. L. Beranek, T. Mellow, *Acoustics: Sound Fields and Transducers*, Elsevier
4. F.P. Mechel, *Formulas of Acoustics 2nd Edition*, Springer
5. T.D. Rossing, N.H. Fletcher, *Principles of Vibration and Sound 2nd Edition*, Springer

Metrology and Measurement Systems

Basic Information
- **Field of Study:** Acoustic Engineering
- **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
- **Study Level:** First-cycle (Engineer) Programme
- **Form of Study:** Full-time Studies
- **Profile:** General Academic
- **Didactic Cycle:** 2021/2022
- **Course Code:** RIAKS.Ii4K.02290.21
- **Lecture Languages:** Polish
- **Mandatoriness:** Obligatory
- **Block:** Core Modules
- **Course Related to Scientific Research:** Yes
- **Course Coordinator:** Ryszard Sroka
- **Lecturers:** Marek Stencel, Ryszard Sroka
- **Period:** Semester 3

Activities and Hours
- **Lectures:** 14 hours
- **Laboratory Classes:** 14 hours
- **ECTS Credits:** 2

Course Goals
- C1: Introduce students to the fundamental methods and tools used in electrical measurements, including uncertainty evaluation and the design of measurement systems.

Learning Outcomes

Knowledge:
- **W1:** Understands basic concepts in electrical metrology.
- **W2:** Possesses foundational knowledge of measurement signals, their parameters, and methods used in electrical measurements.
- **W3:** Understands the construction, operating principles, and signal processing in basic analog and digital measurement devices.

Skills:
- **U1:** Can independently use subject literature and other resources, plan team work, and work safely within a team.
- **U2:** Can analyze simple measurement systems for suitability in specific applications and identify potential sources of uncertainty.

• **U3:** Can perform measurements of basic electrical quantities, process the results with uncertainty estimation, and prepare proper documentation.

Social Competences:
• **K1:** Is aware of ongoing changes in measurement techniques and the need for continuous self-education.
• **K2:** Understands personal and team responsibilities and is ready to adhere to teamwork principles.

Student Workload
• **Lectures:** 14 hours
• **Laboratory Classes:** 14 hours
• **Preparation for Classes:** 10 hours
• **Independent Tasks:** 10 hours
• **Project/Report Preparation:** 10 hours
• **Total Workload:** 58 hours
• **Teacher Workload:** 28 hours

Program Content

1. **Introduction and Formalities:**
   • Overview, safety (BHP), and organizational aspects.
   (Activities: Laboratory Classes)

2. **Basic Measurement Concepts:**
   • Definitions: measurement, physical object, measured quantity, scale, result, tool, system.
   • Fundamental measurement methods.
   (Activities: Lectures)

3. **Standards and Units:**
   • SI system, basic and supplementary units, multiples and submultiples.
   • Standards for electrical quantities (current, voltage, resistance, capacitance, inductance, time, frequency).
   (Activities: Lectures)

4. **Oscilloscope Applications:**
   • Practical use of the oscilloscope in measurements.
   (Activities: Lectures and Laboratory Classes)

5. **Error and Uncertainty:**
   • Concepts of relative/absolute error, deterministic/random errors, limit error, and both standard and expanded uncertainty.
   • Methods for uncertainty calculation in direct and indirect measurements.
   (Activities: Lectures and Laboratory Classes)

6. **Measurements of Electrical Quantities:**
   - Techniques for measuring resistance, impedance, and signal parameters.
   - A/D and D/A converter principles.

   (Activities: Lectures and Laboratory Classes)

Teaching Methods
Lectures, Discussion, and Group Work

Methods of Verification and Credit Conditions
• **Lectures:** Tested via class tests (with active participation considered).
• **Laboratory Classes:** Verified by execution of exercises, lab reports, and test results (attendance mandatory).

Prerequisites:
Basic knowledge of mathematics, physics, and circuit theory.

Literature
• **Obligatory:**

1. Zatorski A., Sroka R.: *Podstawy metrologii elektrycznej*, AGH, Kraków, 2011.
2. Zatorski A., Rozkrut A.: *Miernictwo elektryczne. Materiały do ćwiczeń laboratoryjnych* (Skrypt AGH), various years.
3. Chwaleba A., Poniński M., Siedlecki A.: *Metrologia elektryczna*, WNT, Warszawa, 2003.
4. Marcyniuk A., Pasecki E., Pluciński M., Szadkowski B.: *Podstawy metrologii elektrycznej*, WNT, Warszawa, 1984.
5. Zatorski A., Sroka R.: *Podstawy metrologii elektrycznej. Przykłady i testy*, AGH, Kraków, 2018.

• **Optional:**

1. Skubis T.: *Opracowanie wyników pomiarów – przykłady*, Wydawnictwo Politechniki Śląskiej, Gliwice, 2003.

Programming in LabVIEW

Basic Information
• **Field of Study:** Acoustic Engineering
• **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
• **Study Level:** First-cycle (Engineer) Programme
• **Form of Study:** Full-time Studies
• **Profile:** General Academic
• **Didactic Cycle:** 2021/2022
• **Course Code:** RIAKS.Ii4K.03885.21
• **Lecture Languages:** Polish
• **Mandatoriness:** Obligatory
• **Block:** Core Modules
• **Course Related to Scientific Research:** Yes
• **Course Coordinator:** Paweł Pawlik
• **Lecturer:** Paweł Pawlik
• **Period:** Semester 3

Activities and Hours
• **Laboratory Classes:** 24 hours
• **Project Classes:** 6 hours
• **Number of ECTS Credits:** 2

Course Goals
• Introduce students to the fundamentals of programming with an emphasis on algorithm implementation and programming methodologies.
• Provide organized knowledge in basic programming, signal processing fundamentals, and techniques for algorithm development in LabVIEW.

Learning Outcomes

Knowledge:
• **W1:** Possesses knowledge of programming fundamentals, algorithm implementation, and programming methodologies.
• **W2:** Has organized knowledge in the basics of signal theory and methods of signal analysis and processing.

Skills:
• **U1:** Can design simple signal processing algorithms, estimate task duration, and develop and execute work schedules to meet deadlines.

• **U2:** Can prepare and deliver a concise presentation on the outcomes of an engineering project.

Student Workload
• **Laboratory Classes:** 24 hours
• **Project Classes:** 6 hours
• **Preparation for Classes:** 12 hours
• **Independent Tasks:** 8 hours
• **Total Workload:** 50 hours
• **Teacher Workload:** 30 hours

Program Content

1. **Project Introduction and Discussion:**
   • Overview of project topics, common issues in LabVIEW programming, and student project presentations.
   (Learning Outcomes: W1, U1, U2; Activities: Project Classes)

2. **LabVIEW Environment and Basic Programming:**
   • Hands-on use of LabVIEW, creating a first program, software documentation, debugging, and testing.
   • Operations on arrays and variables; use of WHILE and FOR loops; algorithm implementation; graphical data presentation; file I/O.
   • Application structures: state machine and producer-consumer models; measurement using a sound card; configuration of a measurement card; creation of automatic reports and executable applications; final exam project.
   (Learning Outcomes: W1, W2, U1; Activities: Laboratory Classes)

Teaching Methods
Discussion

Methods of Verification and Credit Conditions
• **Laboratory Classes:** Evaluated through project execution, lab performance, and tests.
• **Project Classes:** Evaluated based on project work, presentation, and test results.

Literature
• **Obligatory:**
1. LabVIEW Core 1 Course Manual – National Instruments Corporation
2. LabVIEW Core 2 Course Manual – National Instruments Corporation

3. *Przykłady cyfrowego przetwarzania w LabVIEW* – Świsulski Dariusz, Wydawnictwo Politechniki Gdańskiej, 2014

• **Optional:**

1. *Komputerowe Systemy Pomiarowe* – Waldemar Nawrocki, Wydawnictwa Komunikacji i Łączności WKŁ, 2007

Programming in MATLAB

Basic Information
- **Field of Study:** Acoustic Engineering
- **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
- **Study Level:** First-cycle (Engineer) Programme
- **Form of Study:** Full-time Studies
- **Profile:** General Academic
- **Didactic Cycle:** 2021/2022
- **Course Code:** RIAKS.Ii4K.02516.21
- **Lecture Languages:** Polish
- **Mandatoriness:** Obligatory
- **Block:** Core Modules
- **Course Related to Scientific Research:** Yes
- **Course Coordinator:** Agnieszka Ozga
- **Lecturers:** Agnieszka Ozga, Robert Barański
- **Period:** Semester 3

Activities and Hours
- **Lectures:** 20 hours
- **Laboratory Classes:** 42 hours
- **Number of ECTS Credits:** 6

Course Goals
- C1: Introduce students to programming in MATLAB’s scripting language and the SIMULINK package, with a focus on the representation and analysis of digital audio signals.

Learning Outcomes

Knowledge:
- **W1:** Able to program in MATLAB’s scripting language.
- **W2:** Capable of processing, archiving, and reproducing acoustic signals.

Skills:
- **U1:** Utilize MATLAB for data visualization in 2D, 3D, and animations.
- **U2:** Select appropriate numerical methods for specific computational tasks.
- **U3:** Define simulation conditions and build simulation models of real systems using SIMULINK.

Social Competences:
- **K1:** Conduct all phases of problem-solving—from data collection and analysis to final report generation.

Student Workload
• **Lectures:** 20 hours
• **Laboratory Classes:** 42 hours
• **Preparation for Classes:** 20 hours
• **Independent Tasks:** 30 hours
• **Project/Report Preparation:** 50 hours
• **Total Workload:** 162 hours
• **Teacher Workload:** 62 hours

Program Content

1. **Introduction & MATLAB Basics:**
   • Overview of course structure, formal requirements, and computer lab usage.
   • General characteristics of MATLAB: help resources, configuration, numeric representation, vectors, matrices, tables, linear algebra, and solving equations.
   (Learning Outcomes: W1, W2, U1, U2, K1; Activities: Lectures, Laboratory Classes)

2. **Tables and Cells:**
   • Working with tables and time-indexed cell arrays.
   (Learning Outcomes: W1, U1, K1; Activities: Lectures, Laboratory Classes)

3. **Scripts, Functions, and Control Structures:**
   • Creation and usage of scripts and functions (including LiveScript/LiveFunction), conditional statements, variable scope, loops, and data selection.
   (Learning Outcomes: W1, W2, U1, U2; Activities: Lectures, Laboratory Classes)

4. **2D Graphics:**
   • Generation and manipulation of 2D graphics.
   (Learning Outcomes: W1, W2, U1, U2; Activities: Lectures, Laboratory Classes)

5. **Data Import and Export:**
   • Script-based data import/export and handling multiple files.
   (Learning Outcomes: W1, W2, U1, U2; Activities: Lectures, Laboratory Classes)

6. **3D Graphics and Animations:**
   • Creation of 3D graphics and animations.
   (Learning Outcomes: W1, W2, U1, U2; Activities: Lectures, Laboratory Classes)

7. **Audio Signal Processing:**
   • Reading and writing audio files, utilizing functions from the Audio Toolbox, and analyzing signals with App Signal Analyzer.
   (Learning Outcomes: W1, W2, U1, U2; Activities: Lectures, Laboratory Classes)

8. **DSP System Toolbox:**
   • Using DSP System Toolbox for processing and analyzing audio signals.
   (Learning Outcomes: W1, W2, U1, U2; Activities: Lectures, Laboratory Classes)

9. **Simulink Applications:**
   • Configuring simulations, data import/export, and building subsystems using SIMULINK with functions from Audio Toolbox and DSP System Toolbox.
   (Learning Outcomes: W1, W2, U1, U2, U3; Activities: Lectures, Laboratory Classes)

10. **Audio Analysis Tools and GUI Development:**
   • Utilizing tools such as filterBuilder and Audio Test Bench; developing graphical interfaces using MATLAB's App Designer.
   (Learning Outcomes: W1, W2, U1, U2, K1; Activities: Lectures, Laboratory Classes)

11. **Symbolic Calculations:**
   • Performing symbolic computations in MATLAB.
   (Learning Outcomes: U2, K1; Activities: Lectures, Laboratory Classes)

12. **Numerical Methods:**
   • Solving interpolation, approximation, and extrapolation problems.
   (Learning Outcomes: U2, K1; Activities: Lectures, Laboratory Classes)

13. **Numerical ODE Solutions:**
   • Methods for solving ordinary differential equations and numerical integration.
   (Learning Outcomes: U2, K1; Activities: Lectures, Laboratory Classes)

14. **Image Analysis:**
   • Basic image analysis in MATLAB.
   (Learning Outcomes: U1, K1; Activities: Lectures, Laboratory Classes)

Teaching Methods
Lectures, E-learning

Methods of Verification and Credit Conditions
• **Lectures:** Assessed by exercises, project execution, laboratory performance, and tests.
• **Laboratory Classes:** Assessed by project execution, laboratory exercises, and tests.

Prerequisites:
Basic knowledge of programming, mathematics, and signal processing.

Literature
• **Obligatory:**

1. MathWorks Website
2. B. Mrozek, Z. Mrozek, *Matlab – Uniwersalne Środowisko do Obliczeń Naukowo-Technicznych*, PLJ, Warszawa, 1996
3. B. Mrozek, Z. Mrozek, *Matlab 6 – Poradnik Użytkownika*, Ago, Kraków, 1994
4. A. Björck, G. Dahlquist, *Metody Numeryczne*, PWN, Warszawa, 1983

5. J. Brzózka, L. Dorobczyński, *Programowanie w Matlab*, MIKOM, Warszawa, 1998
6. M. Stachurski, *Metody Numeryczne w Programie MATLAB*, MIKOM, Warszawa, 2003
7. A. Zalewski, R. Cegiełka, *Matlab – Obliczenia Numeryczne i Ich Zastosowania*, Nakom, Poznań, 1996

Signal Processing 1

Basic Information

- **Field of Study:** Acoustic Engineering
- **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
- **Study Level:** First-cycle (Engineer) Programme
- **Form of Study:** Full-time Studies
- **Profile:** General Academic
- **Didactic Cycle:** 2021/2022
- **Course Code:** RIAKS.Ii4K.02519.21
- **Lecture Languages:** Polish
- **Mandatoriness:** Obligatory
- **Block:** Core Modules
- **Course Related to Scientific Research:** Yes
- **Course Coordinator:** Konrad Kowalczyk
- **Lecturers:** Mariusz Ziółko, Przemysław Sypka
- **Period:** Semester 3

Activities and Hours

- **Lectures:** 28 hours
- **Auditorium Classes:** 28 hours
- **Number of ECTS Credits:** 6

Course Goals

- C1: Introduce students to the basic definitions and concepts of analog signal theory.

Learning Outcomes

Knowledge:

- **W1:** Understands fundamental definitions and concepts in analog signal theory.

Skills:

- **U1:** Can classify signals and employ mathematical models to represent them.
- **U2:** Is capable of analyzing signals in both the time and frequency domains.
- **U3:** Can design filters for analog signals.
- **U4:** Can interpret literature on signal theory effectively.

Social Competences:

- **K1:** Appreciates the advantages of mathematical modeling for multimedia signal processing systems.

Student Workload
- **Lectures:** 28 hours
- **Auditorium Classes:** 28 hours
- **Preparation for Classes:** 44 hours
- **Independent Tasks:** 43 hours
- **Examination/Final Test:** 2 hours
- **Contact Hours:** 5 hours
- **Total Workload:** 150 hours
- **Teacher Workload:** 56 hours

Program Content

1. **Signal Theory – Part I**
   - Classification of signals (analog, discrete, digital) and their mathematical models; one- and two-dimensional signals.
   - Functional spaces for signals: distances, norms, and scalar products.
   - Representation of signals using elementary functions; orthonormal bases with Haar, Walsh, and trigonometric functions; variable separation in 2D signals.
   - Frequency analysis: Fourier series and transform, signal spectra, and generalized Fourier transform.
   - Local spectral analysis using windowing and Gabor transform.
   - Basics of wavelet theory: examples, scaling functions, and continuous and discrete wavelet transforms.
   - Design of analog filters: mathematical models, transfer functions, impulse responses, and frequency characteristics.

   (Learning Outcomes: W1, U3, U4; Activities: Lectures)

2. **Signal Theory – Part II**
   - Review of signal classification and modeling with elementary one-dimensional analog signals; scaling and shifting operations.
   - Orthonormal representation and functional spaces for signals.
   - Detailed Fourier analysis with interpretation of spectra.
   - Local time–frequency analysis using short-time Fourier and Gabor transforms.
   - Fundamentals of wavelet theory.
   - Final test.

   (Learning Outcomes: U1, U2, U3, U4, K1; Activities: Auditorium Classes)

Teaching Methods
Lectures, Discussion

Literature
- **Obligatory:**

1. Jerzy Szabatin, *Podstawy teorii sygnałów*, Wydawnictwa Komunikacji i Łączności, 1982
2. Jacek Izydorczyk, Grzegorz Płonka, Grzegorz Tyma, *Teoria Sygnałów*, Helion, 1999
3. Kajetana M. Snopek, Jacek M. Wojciechowski, *Sygnały i Systemy: Zbiór Zadań*, Oficyna Wydawnicza Politechniki Warszawskiej, 2010

Theory of Vibration

Basic Information
• **Field of Study:** Acoustic Engineering
• **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
• **Study Level:** First-cycle (Engineer) Programme
• **Form of Study:** Full-time Studies
• **Profile:** General Academic
• **Didactic Cycle:** 2021/2022
• **Course Code:** RIAKS.Ii4K.02517.21
• **Lecture Languages:** Polish
• **Mandatoriness:** Obligatory
• **Block:** Core Modules
• **Course Related to Scientific Research:** No
• **Course Coordinator:** Leszek Majkut
• **Lecturers:** Leszek Majkut, Ryszard Olszewski, Tomasz Korbiel
• **Period:** Semester 3

Activities and Hours
• **Lectures:** 28 hours
• **Auditorium Classes:** 26 hours
• **Laboratory Classes:** 14 hours
• **Number of ECTS Credits:** 6

Course Goals
• C1: Introduce students to fundamental concepts and methods for analyzing vibrations of discrete systems, and to build the knowledge required to design and analyze vibrating systems with one or multiple degrees of freedom, including analogies between mechanical, acoustic, and electrical oscillators.

Learning Outcomes

Knowledge:
• **W1:** Understands basic definitions and methods for analyzing vibrations in discrete systems.
• **W2:** Possesses structured knowledge essential for building and analyzing vibrating systems with one or multiple degrees of freedom.
• **W3:** Understands analogies between vibrating mechanical, acoustic, and electrical systems.

Skills:
• **U1:** Can linearize restitution force characteristics.
• **U2:** Can determine fundamental quantities describing linear vibrations of systems with one or

multiple degrees of freedom.
• **U3:** Can conduct measurements of basic physical quantities and process the results accordingly.

Social Competences:
• **K1:** Demonstrates effective teamwork skills.

Student Workload
• **Lectures:** 28 hours
• **Auditorium Classes:** 26 hours
• **Laboratory Classes:** 14 hours
• **Preparation for Classes:** 41 hours
• **Independent Tasks:** 36 hours
• **Contact Hours:** 5 hours
• **Project/Report Preparation:** 30 hours
• **Total Workload:** 180 hours
• **Teacher Workload:** 68 hours

Program Content

1. **Modeling of Vibrating Systems:**
   • Physical and mathematical modeling, discretization, linearization.
   • Vibrations of linear systems with one degree of freedom (natural, free, and forced), amplitude–frequency characteristics, structural modifications, and vibration isolation.
   • Vibrations in RLC circuits; electro-mechanical-acoustic analogies; resonance in mechanical and electrical systems.
   • Advanced analysis methods: complex functions, impedance method, Laplace transform, Rayleigh method; vibrations of two-degree-of-freedom systems; dynamic damping.

2. **Linearization of Restitution Forces:**
   • Determination of functions describing free and forced vibrations of linear systems with one degree of freedom.
   • Analysis of amplitude–frequency characteristics; influence of structural modifications; design parameters for vibration isolation; applications in RLC circuits and analogies across domains; analysis of systems with two degrees of freedom.

3. **Laboratory Experiments:**
   • Practical modeling of vibrating systems, including experiments on beam vibrations, mathematical pendulums, electro-mechanical analogies, and forced vibrations of beams or two-degree-of-freedom systems.

Teaching Methods
Lectures, Discussion

Literature

- **Obligatory:**

1. Engel, Z., Giergiel, J.: *Dynamika*, Wydawnictwa AGH, Kraków, 2000
2. Osiński, Z.: *Teoria drgań*, PWN, Warszawa, 1978
3. Ziemba, S.: *Analiza drgań*, PWN, Warszawa, 1957
4. Bogusz, W., Engel, Z., Giergiel, J.: *Drgania i szumy*, Wydawnictwa Geologiczne, Warszawa, 1974
5. Giergiel, J.: *Zagadnienia tłumienia drgań*, Wydawnictwa AGH, Kraków, 1974
6. Nizioł, J.: *Podstawy drgań w maszynach*, Wydawnictwo Politechniki Krakowskiej, Kraków, 1996
7. Osiński, Z.: *Tłumienie drgań*, PWN, Warszawa, 1997

Architectural Acoustics

Basic Information

- **Field of Study:** Acoustic Engineering
- **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
- **Study Level:** First-cycle (Engineer) Programme
- **Form of Study:** Full-time Studies
- **Profile:** General Academic
- **Didactic Cycle:** 2021/2022
- **Course Code:** RIAKS.Ii8K.02503.21
- **Lecture Languages:** Polish
- **Mandatoriness:** Obligatory
- **Block:** Core Modules
- **Course Related to Scientific Research:** Yes
- **Course Coordinator:** Tadeusz Kamisiński
- **Lecturers:** Tadeusz Kamisiński, Jarosław Rubacha, Adam Pilch, Artur Flach
- **Period:** Semester 4

Activities and Hours

- **Lectures:** 28 hours
- **Laboratory Classes:** 28 hours
- **Number of ECTS Credits:** 4

Course Goals

- C1: Provide students with the knowledge and skills for designing, measuring, and evaluating the acoustic parameters of rooms, and to understand the role of the acoustician in architectural design.

Learning Outcomes

Knowledge:

- **W1:** Understands methods for measuring basic acoustic parameters of rooms.
- **W2:** Knows techniques for measuring the sound absorption coefficient in a reverberation chamber.
- **W3:** Understands the acoustic requirements for qualified spaces.
- **W4:** Can list material properties relevant to acoustic adaptations.

Skills:

- **U1:** Can design measurement setups for evaluating sound absorption, acoustic parameters, and acoustic power.
- **U2:** Can perform measurements using appropriate equipment and estimate measurement

duration.
• **U3:** Can process acoustic data according to relevant norms and legal standards.
• **U4:** Can analyze a room's acoustics to determine the need and scope for acoustic adaptation.

Social Competences:
• **K1:** Can collaborate with specialists from related fields (e.g., ventilation, HVAC, sanitary installations).
• **K2:** Is aware of the requirements of musicians, conductors, producers, and lighting designers, integrating these into acoustic design guidelines.

Student Workload
• **Lectures:** 28 hours
• **Laboratory Classes:** 28 hours
• **Preparation for Classes:** 24 hours
• **Contact Hours:** 5 hours
• **Project/Report Preparation:** 35 hours
• **Total Workload:** 120 hours
• **Teacher Workload:** 56 hours

Program Content

1. **Introduction to Architectural Acoustics:**
   • Overview of acoustics in architectural contexts, historical examples (amphitheaters, churches, concert halls), and key acoustic dimensions.
   (Activities: Lectures)

2. **Acoustic Properties of Building Materials:**
   • Examination of typical building structures (walls, ceilings, roofs) and their impact on room acoustics.
   (Activities: Lectures)

3. **Modeling the Acoustic Field:**
   • Principles of acoustic field modeling (physical, wave, geometric, statistical models); methods such as image source and ray tracing for numerical modeling.
   (Activities: Lectures)

4. **Acoustic Parameters of Rooms:**
   • Differentiation between objective and subjective parameters; measurement methods and data interpretation.
   (Activities: Lectures)

5. **Requirements for Qualified Spaces:**
   • Discussion of acoustic standards and recommendations for spaces such as concert halls and opera houses.
   (Activities: Lectures)

6. **Small Room Acoustics:**
   • Fundamentals of designing small rooms: modal analysis, geometry selection, and early reflection management.
   (Activities: Lectures)

7. **Acoustic Adaptation Techniques:**
   • Strategies for acoustic treatment (e.g., diffusers, absorbers, adjustable elements) to eliminate acoustic flaws.
   (Activities: Lectures)

8. **Case Studies:**
   • Review of real-world projects and analysis of architectural drawings to identify and resolve acoustic issues.
   (Activities: Lectures)

9. **Measurement of Reverberation Time:**
   • Methods for measuring reverberation time using impulse response integration and noise methods.
   (Activities: Laboratory Classes)

Teaching Methods
Lectures, Discussion, Group Work, Problem-Based Learning, Case Studies

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Literature

• **Obligatory:**

1. Barron M., *Auditorium Acoustics and Architectural Design*, Spon Press, London, 2009
2. Beranek L., *Concert Halls and Opera Houses*, Springer, 2010
3. Everest F.A., *Podręcznik Akustyki*, Wydawnictwo SONIA DRAGA, Katowice, 2009
4. Makarewicz R., *Dźwięki i Fale*, Wydawnictwo UAM, Poznań, 2003
5. Kulowski A., *Akustyka Sal*, Wydawnictwo PG, Gdańsk, 2011
6. Kuttruff H., *Room Acoustics*, Taylor & Francis, London, 2009

• **Optional:**

1. Makarewicz R., *Wstęp do Akustyki Teoretycznej*, Wydawnictwo UAM, Poznań, 2005

Electroacoustics

Basic Information
- **Field of Study:** Acoustic Engineering
- **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
- **Study Level:** First-cycle (Engineer) Programme
- **Form of Study:** Full-time Studies
- **Profile:** General Academic
- **Didactic Cycle:** 2021/2022
- **Course Code:** RIAKS.Ii8K.02507.21
- **Lecture Languages:** Polish
- **Mandatoriness:** Obligatory
- **Block:** Core Modules
- **Course Related to Scientific Research:** Yes
- **Course Coordinator:** Maciej Kłaczyński
- **Lecturers:** Maciej Kłaczyński, Grażyna Wszołek, Wiesław Wszołek, Artur Flach
- **Period:** Semester 4

Activities and Hours
- **Lectures:** 28 hours
- **Laboratory Classes:** 28 hours
- **Number of ECTS Credits:** 4

Course Goals
- C1: Familiarize students with the construction and operating principles of electroacoustic transducers—including microphones, loudspeakers (including tube speakers), speaker enclosures, speaker systems, electrical crossovers, and headphones.

Learning Outcomes

Knowledge:
- **W1:** Possesses advanced knowledge of electroacoustics and understands the analogies among mechanical, electrical, and acoustic systems, including model synthesis.
- **W2:** Has comprehensive knowledge of electroacoustic transducers, including their operating principles, construction, and applications.
- **W3:** Understands general principles of sound reinforcement for both open spaces and enclosed rooms.

Skills:
- **U1:** Can select and configure components of an acoustic signal chain and perform test measurements.

• **U2:** Can plan, execute, and analyze measurement results for typical electroacoustic transducers.

Social Competences:
• **K1:** Demonstrates effective teamwork in preparing, executing, and reporting acoustic system control results.

Student Workload
• **Lectures:** 28 hours
• **Laboratory Classes:** 28 hours
• **Preparation for Classes:** 36 hours
• **Independent Tasks:** 16 hours
• **Project/Report Preparation:** 10 hours
• **Total Workload:** 120 hours
• **Teacher Workload:** 56 hours

Program Content

1. **Fundamentals and System Models:**
   • Introduction to electroacoustic principles, including analogies between mechanical, electrical, and acoustic systems; basic filter concepts.
   (Activities: Lectures)
2. **Microphones:**
   • Types and classifications; key parameters; measurement and calibration methods for acoustic transducers.
   (Activities: Lectures)
3. **Loudspeakers and Related Equipment:**
   • Operation and design of speakers, speaker enclosures, electrical crossovers, and arrays; overview of tube speakers and headphones.
   (Activities: Lectures)

Teaching Methods
Lectures, Discussion, Laboratory Exercises

Literature
• **Obligatory:**
1. M. Kleiner – *Electroacoustics*, CRC Press, 2013
2. F. Jacobsen – *Sound Intensity and Its Measurement and Applications* (available online)
3. L. Kinsler, A. Frey, A. Coppens, J. Sanders – *Fundamentals of Acoustics*
4. F. Fahy – *Engineering Acoustics*

5. *Handbook for Sound Engineers, Part 3 – Electroacoustic Devices*, ed. G. Ballou
6. A. Dobrucki – *Przetworniki elektroakustyczne*, WNT, 2007
7. F. Everest – *Podręcznik akustyki*, WSD Sp. z o.o., 2004
8. Z. Żyszkowski – *Miernictwo akustyczne*, WNT, 1987
9. Z. Żyszkowski – *Podstawy elektroakustyki*, WNT, 1984
10. B. Urbański – *Elektroakustyka w pytaniach i odpowiedziach*, WNT, 1984

• **Optional:**

1. T. Skubis – *Opracowanie wyników pomiarów – przykłady*, Wydawnictwo Politechniki Śląskiej, 2003

Mathematical Methods in Acoustics

Basic Information

- **Field of Study:** Acoustic Engineering
- **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
- **Study Level:** First-cycle (Engineer) Programme
- **Form of Study:** Full-time Studies
- **Profile:** General Academic
- **Didactic Cycle:** 2021/2022
- **Course Code:** RIAKS.Ii8P.02501.21
- **Lecture Languages:** Polish
- **Mandatoriness:** Obligatory
- **Block:** Foundation Modules
- **Course Related to Scientific Research:** Yes
- **Course Coordinator:** Łukasz Gorazd
- **Lecturer:** Łukasz Gorazd
- **Period:** Semester 4

Activities and Hours

- **Lectures:** 26 hours
- **Auditorium Classes:** 26 hours
- **Number of ECTS Credits:** 4

Course Goals

- C1: Introduce students to mathematical methods for describing acoustic phenomena and systems.
- C2: Convey mathematical knowledge applicable in acoustic engineering.

Learning Outcomes

Knowledge:

- **W1:** Acquires knowledge from selected mathematical branches necessary for analytical acoustics, including fundamentals of vector field calculus, theory of analytic functions, differential equations, special functions, and integral transforms.

Skills:

- **U1:** Can apply learned mathematical methods for model analysis of acoustic processes and technical solutions.
- **U2:** Can use mathematical tools to describe and analyze both model and real acoustic fields (e.g., using vector calculus, complex notation, solving basic differential equations, and applying

integral transforms).
• **U3:** Can integrate theoretical mathematical models with practical engineering applications.

Social Competences:
• **K1:** Recognizes the need for continuous learning to enhance professional and social competencies.

Student Workload
• **Lectures:** 26 hours
• **Auditorium Classes:** 26 hours
• **Preparation for Classes:** 30 hours
• **Independent Tasks:** 30 hours
• **Final Exam:** 2 hours
• **Contact Hours:** 5 hours
• **Total Workload:** 119 hours
• **Teacher Workload:** 52 hours

Program Content

1. **Analysis of Physical Fields:**
   • Description of physical fields in Cartesian and orthogonal curvilinear systems using scalar and vector potentials.
   (Activities: Lectures)
2. **Acoustic Field Modeling:**
   • Modeling the acoustic field in fluid media using the nabla operator (gradient, divergence, curl) in both Cartesian and selected curvilinear coordinates.
   (Activities: Lectures)
3. **Continuity Equations:**
   • Differential and integral forms of mass, momentum, and energy continuity; applications of Gauss's, Stokes', and Green's theorems.
   (Activities: Lectures)
4. **Ordinary Differential Equations:**
   • Fundamentals of linear homogeneous and non-homogeneous ODEs with constant coefficients; series solutions (Frobenius method) for second-order equations in acoustics.
   (Activities: Lectures)
5. **Special Functions in Acoustics:**
   • Solutions of Legendre's and Bessel's equations (including Neumann's and Hankel's functions) and their applications in modeling vibrating circular pistons.
   (Activities: Lectures)

6. **Wave and Helmholtz Equations:**
   • Solving these equations in Cartesian, cylindrical, and spherical coordinates via separation of variables; interpretation of boundary conditions.
   (Activities: Lectures)

7. **Green's Function Method:**
   • Use of Green's functions for the wave and Helmholtz equations in one, two, and three dimensions.
   (Activities: Lectures)

8. **Eigenvalue Problems:**
   • Helmholtz equation as an eigenvalue problem and the development of complete orthogonal systems in various coordinate systems (e.g., Fourier series, Legendre polynomials, spherical harmonics).
   (Activities: Lectures)

9. **Complex Variable Methods:**
   • Basics of complex numbers and elementary functions; Euler's formula; properties of analytic functions, singularities, residues; and applications in acoustic field theory.
   (Activities: Lectures)

Teaching Methods
Lectures, Group Work

Literature
• **Obligatory:**
1. D. McQuarrie, *Matematyka dla przyrodników i inżynierów*, PWN
2. A. Lenda, *Matematyczne metody fizyki*, Wyd. AGH

• **Optional:**
1. K.A. Stroud, D.J. Booth, *Engineering Mathematics*
2. R.J. Lopez, *Advances in Engineering Mathematics*, Addison Wesley
3. Online Resource – K. Golec-Biernat, *Metody matematyczne*
4. E. Skudrzyk, *Foundations of Acoustics* (selected chapter) – Springer
5. R. Wyrzykowski, *Metody matematyczne fizyki*, Wyd. Oświatowe FOSZE, 1995
6. R. Wyrzykowski, *Metody matematyczne w akustyce teoretycznej*
7. F.W. Byron, R.W. Fuller, *Matematyka w fizyce klasycznej i kwantowej*, PWN

Principles of Music

Basic Information
• **Field of Study:** Acoustic Engineering
• **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
• **Study Level:** First-cycle (Engineer) Programme
• **Form of Study:** Full-time Studies
• **Profile:** General Academic
• **Didactic Cycle:** 2021/2022
• **Course Code:** RIAKS.Ii8K.02598.21
• **Lecture Languages:** Polish
• **Mandatoriness:** Elective
• **Block:** Core Modules
• **Course Related to Scientific Research:** Yes
• **Course Coordinator:** Marek Pluta
• **Lecturer:** Marek Pluta, Adam Pilch
• **Period:** Semester 4
• **Method of Verification of Learning Outcomes:** Completion of Classes

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Activities and Hours
• **Lectures:** 14 hours
• **Laboratory Classes:** 13 hours
• **Number of ECTS Credits:** 2

Course Learning Outcomes

Knowledge:
• **W1:** Understands the significance of musical notation elements.
• **W2:** Has knowledge of the elements of a musical piece and their relationship with the physical parameters of sound.

Skills:
• **U1:** Can read and write basic musical notation.
• **U2:** Can determine the exact or approximate values of physical sound parameters related to specific musical notation elements.

Methods of Verification: Activity during classes, execution of laboratory classes, tests, oral responses.

Student Workload
• **Lectures:** 14 hours
• **Laboratory Classes:** 13 hours

- **Preparation for Classes:** 13 hours
- **Independent Tasks:** 12 hours
- **Total Workload:** 52 hours
- **Teacher Workload:** 27 hours

Program Content

1. **Rhythm:** Note values, binary and ternary subdivisions. *(Lectures)*
2. **Meter and Time Signatures:** Grouping of rhythmic values. *(Lectures)*
3. **Staff and Treble Clef:** Scale, note names, and positions on the staff and piano keyboard. *(Lectures)*
4. **Accidentals and Scales:** Sharp, flat, natural signs; major second intervals; C major scale. *(Lectures)*
5. **Melody and Intervals:** Frequency ratios in musical intervals. *(Lectures)*
6. **Major-Minor System:** Tonality, circle of fifths, other scales. *(Lectures)*
7. **Harmony:** Basic harmonic intervals and triads. *(Lectures)*
8. **Four-Note Chords:** Structure and function. *(Lectures)*
9. **Chord Inversions:** Inversions of intervals, triads, and four-note chords. *(Lectures)*
10. **Articulation:** Symbols and terminology. *(Lectures)*
11. **Dynamics:** Dynamic markings. *(Lectures)*
12. **Tempo and Agogics:** Tempo markings. *(Lectures)*
13. **Clefs and Key Signatures:** Alternative clefs and their applications. *(Lectures)*
14. **Other Notational Symbols:** Additional notation elements. *(Lectures)*
15. **Musical Score Reading:** Examples of notation for various instruments and ensembles. *(Lectures)*
16. **Rhythmic Exercises:** Notation and conducting patterns. *(Laboratory Classes)*
17. **Rhythmic Grouping:** Simple and compound meters, transformations. *(Laboratory Classes)*
18. **Pitch Notation in Treble Clef:** Interval identification. *(Laboratory Classes)*
19. **Bass and Alto Clefs:** Notation with accidentals, building intervals. *(Laboratory Classes)*
20. **Key Signatures:** Determination of keys, major and minor scales. *(Laboratory Classes)*
21. **Triad Notation and Recognition:** Writing, identifying, and listening to triads. *(Laboratory Classes)*

22. **Four-Note Chords:** Writing, recognizing, and listening to inversions. *(Laboratory Classes)*

Teaching Methods
Lectures, Discussion

Literature

Obligatory:

1. Wesołowski F., *Zasady muzyki*, PWM, Kraków 2010.

Optional:

1. Lasocki J.K., *Podstawowe wiadomości z nauki o muzyce*, PWM, Kraków 2004.

Signal Processing 2

Basic Information

- **Field of Study:** Acoustic Engineering
- **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
- **Study Level:** First-cycle (Engineer) Programme
- **Form of Study:** Full-time Studies
- **Profile:** General Academic
- **Didactic Cycle:** 2021/2022
- **Course Code:** RIAKS.Ii8K.02520.21
- **Lecture Languages:** Polish
- **Mandatoriness:** Obligatory
- **Block:** Core Modules
- **Course Related to Scientific Research:** Yes
- **Course Coordinator:** Jakub Gałka
- **Lecturers:** Marcin Witkowski, Jakub Gałka
- **Period:** Semester 4

Activities and Hours

- **Lectures:** 28 hours
- **Laboratory Classes:** 28 hours
- **Number of ECTS Credits:** 4

Course Goals

- **C1:** Introduce students to fundamental concepts and algorithms in digital signal processing.
- **C2:** Develop practical skills in analyzing and designing digital signal processing systems.

Learning Outcomes

Knowledge:
- **W1:** Understands fundamental definitions, concepts, and algorithms in digital signal processing.

Skills:
- **U1:** Can apply digital signal processing tools and algorithms.
- **U2:** Can analyze signals and systems in both time and frequency domains.
- **U3:** Can design basic digital signal processing systems.
- **U4:** Can interpret information from literature on signal processing.

Social Competences:
• **K1:** Understands the need to communicate knowledge about signal processing in an accessible way, including through mass media.

Student Workload

• **Lectures:** 28 hours
• **Laboratory Classes:** 28 hours
• **Preparation for Classes:** 20 hours
• **Independent Tasks:** 40 hours
• **Final Exam:** 2 hours
• **Contact Hours:** 2 hours
• **Total Workload:** 120 hours
• **Teacher Workload:** 56 hours

Program Content

1. **Introduction to Digital Signal Processing**
   • Sampling theory, Shannon's theorem, aliasing
   • Analog-to-digital and digital-to-analog conversion
   • Quantization noise

2. **Frequency Analysis of Digital Signals**
   • Comparison of frequency analysis in analog and discrete signals
   • Discrete Fourier Transform (DFT), properties, and inverse DFT
   • Fast Fourier Transform (FFT) algorithm and its applications

3. **Digital Filters**
   • Z-transform and its relation to the Fourier transform
   • Linear systems and spectral shaping
   • Finite Impulse Response (FIR) filters – properties and design methods
   • Infinite Impulse Response (IIR) filters – stability and design

4. **Fundamentals of Signal Compression**
   • Elements of information theory
   • Lossless and lossy compression methods
   • Huffman coding, arithmetic coding, scalar and vector quantization

5. **Multimedia Signal Compression**
   • Transform coding and discrete cosine transform (DCT)
   • Image compression – JPEG format
   • Audio compression – speech coding (CELP), MP3 coding

6. **Laboratory Classes (28 hours)**
   • Introduction to MATLAB and DSP tools
   • Signal sampling and aliasing experiments

- Fourier transform properties and applications
- Fast Fourier Transform and spectral density estimation
- Z-transform and system representation
- FIR and IIR filter design and implementation
- Digital signal resampling and practical applications
- Lossless and lossy signal compression techniques

Teaching Methods

Lectures, Laboratory Work, Group Discussions

Literature

Obligatory:

1. Bartosz Ziółko, Mariusz Ziółko – *Przetwarzanie mowy*, AGH 2011
2. Tomasz Zieliński – *Cyfrowe przetwarzanie sygnałów*, WKŁ 2005
3. Richard G. Lyons – *Wprowadzenie do cyfrowego przetwarzania sygnałów*, WKŁ 1999, 2000

Optional:

4. Dag Stranneby – *Cyfrowe przetwarzanie sygnałów*, BTC 2004
5. Włodzimierz Kwiatkowski – *Wstęp do cyfrowego przetwarzania sygnałów*, Warszawa 2003
6. Marian Pasko, Janusz Walczak – *Teoria sygnałów*, Wyd. Politechniki Śląskiej, 1999
7. Jacek Izydorczyk, Grzegorz Płonka, Grzegorz Tyma – *Teoria Sygnałów*, Helion 1999

Statistics for Acoustics

Basic Information

- **Field of Study:** Acoustic Engineering
- **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
- **Study Level:** First-cycle (Engineer) Programme
- **Form of Study:** Full-time Studies
- **Profile:** General Academic
- **Didactic Cycle:** 2021/2022
- **Course Code:** RIAKS.Ii8K.07473.21
- **Lecture Languages:** Polish
- **Mandatoriness:** Obligatory
- **Block:** Core Modules
- **Course Related to Scientific Research:** Yes
- **Course Coordinator:** Agnieszka Ozga
- **Lecturer:** Agnieszka Ozga
- **Period:** Semester 4

Activities and Hours

- **Lectures:** 28 hours
- **Laboratory Classes:** 28 hours
- **Number of ECTS Credits:** 4

Course Goals

- **C1:** Introduce students to the quantitative description of causal relationships in technical and natural processes. Provide knowledge of correlation studies, hypothesis testing, significance analysis, and parameter estimation.

Learning Outcomes

Knowledge:

- **W1:** Understands how statistical studies are used to design, conduct, analyze, visualize, and validate measurements.
- **W2:** Has knowledge of statistical inference.

Skills:

- **U1:** Can formulate and test statistical hypotheses.
- **U2:** Can estimate statistical parameters.
- **U3:** Can define a problem, describe data, and visualize it.

Social Competences:
• **K1:** Understands the importance of reliable data analysis.

Student Workload

• **Lectures:** 28 hours
• **Laboratory Classes:** 28 hours
• **Preparation for Classes:** 18 hours
• **Independent Tasks:** 10 hours
• **Preparation of Project/Presentation/Report:** 36 hours
• **Total Workload:** 120 hours
• **Teacher Workload:** 56 hours

Program Content

1. **Introduction to Survey and Experimental Data Analysis**
   • Measurement scales and variable types
   • Specifics of measurement in social and engineering sciences
2. **Fundamentals of Probability Theory – Review**
   • Probability distributions
   • Calculating probabilities based on the normal distribution
   • Central limit theorem
3. **Statistical Series and Data Visualization Techniques**
   • Descriptive statistics
4. **Introduction to Hypothesis Testing**
   • Statistical power of tests
5. **Nonparametric Tests**
6. **Statistical Series and Hypothesis Testing**
7. **Tests for Data from Acoustic Measurements**
8. **Interval Estimation**
9. **Point Estimation**
10. **Regression Analysis**
11. **Analysis of Variance (ANOVA)**
12. **Measurement Error Analysis**
   • Measurement uncertainty issues
   • Statistical tests for detecting errors
13. **Validation of Measurement Methods**

14. **Classification and Pattern Recognition**
    • Introduction to machine learning

Teaching Methods

Lectures, Discussions, Laboratory Work, E-learning

Literature

Obligatory:

1. Andrzej Zięba – *Analiza danych w naukach ścisłych i w technice*, Wydawnictwo Naukowe PWN, 2014
2. Grażyna Wieczorkowska, Jerzy Wierzbiński – *Statystyka od teorii do praktyki*, Wydawnictwo Naukowe Scholar, 2011
3. Anna Koziarska, Andrzej Metelski – *Statystyka dla studentów kierunków inżynierskich*, Politechnika Opolska, 2016

Vibroacoustical Metrology

Basic Information

- **Field of Study**: Acoustic Engineering
- **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
- **Study Level**: First-cycle (Engineer) Programme
- **Form of Study**: Full-time Studies
- **Profile**: General Academic
- **Didactic Cycle**: 2021/2022
- **Course Code**: RIAKS.Ii8K.02511.21
- **Lecture Languages**: Polish
- **Mandatoriness**: Obligatory
- **Block**: Core Modules
- **Course Related to Scientific Research**: Yes
- **Course Coordinator**: Tadeusz Wszołek
- **Lecturers**: Tadeusz Wszołek, Maciej Kłaczyński
- **Period**: Semester 4

Activities and Hours

- **Lectures**: 14 hours
- **Laboratory Classes**: 26 hours
- **Number of ECTS Credits**: 3

Course Goals

- **C1**: Introduce students to methods and techniques for measuring acoustic and vibrational quantities.
- **C2**: Develop practical skills in analyzing and evaluating vibroacoustic signals and systems.

Learning Outcomes

- **Knowledge**:
  - **W1**: Understands metrology and methods for measuring key acoustic and vibration quantities.
  - **W2**: Knowledge of advanced measuring techniques and uncertainty analysis in vibroacoustic measurements.
- **Skills**:
  - **U1**: Can parameterize and calibrate measurement systems for acoustic and vibration quantities.
  - **U2**: Can perform reverberation time measurements in various environments.
  - **U3**: Capable of performing spectral analysis of acoustic and vibration signals in both field and indoor conditions.
  - **U4**: Can analyze and assess measurement results for vibrations and noise, including uncertainty evaluation.
  - **U5**: Understands the use of legal regulations related to noise and vibration measurements.
- **Social Competences**:
  - **K1**: Can work effectively in teams and communicate using professional terminology.

Student Workload

- **Lectures**: 14 hours
- **Laboratory Classes**: 26 hours
- **Preparation for Classes**: 12 hours
- **Independent Tasks**: 12 hours
- **Examination**: 2 hours
- **Total Workload**: 84 hours

Program Content

1. **Introduction to Vibroacoustic Signals**: Characteristics of time-varying signals, measurable parameters.
2. **Transducers for Acoustic and Vibration Measurements**: Microphones and accelerometers – types, parameters, and calibration.

3. **Frequency Analysis of Signals**: Using filters and FFT for analyzing sinusoidal, sawtooth, and square wave signals.
4. **Signal Filtering**: Using bandpass filters in measurement systems.
5. **Noise Signals Analysis**: Study of white, pink, and red noise using FFT.
6. **Measurement of Acoustic and Vibration Parameters**: Techniques for measuring noise and vibration indicators like LEQ, SEL, displacement, and acceleration.
7. **Calibration of Measurement Systems**: Calibration of acoustic and vibration systems with appropriate sources and standards.
8. **Uncertainty in Vibroacoustic Measurements**: Defining and calculating measurement uncertainties in vibroacoustic systems.
9. **Field Measurements**: Practical applications for measuring road traffic noise and vibrations.
10. **Reverberation Time Measurement**: Techniques for measuring reverberation time using various signal methods.

Teaching Methods

- **Lectures**: Theoretical instruction on vibroacoustic metrology concepts.
- **Laboratory Classes**: Hands-on experiments with acoustic and vibration measurement tools.

Literature

- **Obligatory**:
    1. B&K – Acoustics Noise Measurements
    2. B&K – Mechanical Vibration and Shock Measurements
    3. PN-ISO 1996-1:2006 – Acoustic Noise Measurement Standards

Analog Electronic Circuits

Basic Information

- **Field of Study**: Acoustic Engineering
- **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
- **Study Level**: First-cycle (Engineer) Programme
- **Form of Study**: Full-time Studies
- **Profile**: General Academic
- **Didactic Cycle**: 2021/2022
- **Course Code**: RIAKS.Ii10K.02592.21
- **Lecture Languages**: Polish
- **Mandatoriness**: Obligatory
- **Block**: Core Modules
- **Course Related to Scientific Research**: No
- **Course Coordinator**: Dariusz Kościelnik
- **Lecturers**: Piotr Dziurdzia, Dariusz Kościelnik
- **Period**: Semester 5
- **Method of Verification of Learning Outcomes**: Exam

Activities and Hours

- **Lectures**: 28 hours
- **Auditorium Classes**: 28 hours
- **Laboratory Classes**: 28 hours
- **Number of ECTS Credits**: 8

Course Learning Outcomes

- **Knowledge**:
  - **W1**: Understands basic solutions in bipolar and CMOS technology for typical electronic circuits.
  - **W2**: Knows principles of designing and analyzing analog electronic circuits.

- **Skills**:
  - **U1**: Can design analog electronic circuits using appropriate methods, techniques, and tools.
- **Social Competences**:
  - **K1**: Recognizes the importance of continuous professional development and self-improvement.

Student Workload

- **Lectures**: 28 hours
- **Auditorium Classes**: 28 hours
- **Laboratory Classes**: 28 hours
- **Preparation for Classes**: 48 hours
- **Independent Tasks**: 68 hours
- **Total Workload**: 200 hours

Program Content

1. **Voltage Amplifier Using Bipolar Transistor (OE Configuration)**: Design and measurement of amplifier parameters.
2. **Voltage Amplifier Using Unipolar Transistor (OS Configuration)**: Similar to bipolar design with different transistors.
3. **DC Amplifier**: Measurement of transition characteristics, differential, and summing gain.
4. **Linear Applications of Operational Amplifiers**: Feedback loop design and measurement.
5. **Nonlinear Applications of Operational Amplifiers**: Design of circuits with desired nonlinear characteristics.
6. **Voltage Stabilizers**: Design of parametric and compensation voltage regulators.
7. **Power Amplifier**: Measurement and analysis of power amplifier parameters and distortions.
8. **Multiplying Circuits**: Measurement of multiplying circuits using appropriate structures.
9. **Power Supply and Stabilization**: Analysis of amplifier power supply systems for desired stability.

10. **Noise in Amplifiers**: Mechanisms of noise generation and optimization in electronic circuits.
11. **LC Selective Amplifiers**: Design and measurement of resonant LC circuits for amplification.
12. **Switching Power Supplies**: Analysis of switching regulators and their characteristics.

Teaching Methods

- **Lectures**: Theoretical instruction on analog electronic circuits.
- **Auditorium Classes**: Exercises focused on solving design problems.
- **Laboratory Classes**: Hands-on work with circuit design, measurements, and analysis.

Literature

- **Obligatory**:

1. St. Kuty (Ed.), *Semiconductor Devices and Electronic Circuits Vol. I & II*, AGH Publishing, 2000.
2. J. Baranowski, Z. Nosal, *Electronic Circuits Vol. I & II*, WNT, 1998.
3. P.R. Gray, P.J. Hurst, J.H. Lewis, R.G. Meyer, *Analysis and Design of Analog Integrated Circuits*, 4th ed., Wiley, 2001.
4. P.E. Allen, D.R. Holberg, *CMOS Analog Circuit Design*, Oxford UP, 2002.

Audio Engineering - Fundamentals and Systems

- **Field of Study**: Acoustic Engineering
- **Organisational Unit**: Faculty of Mechanical Engineering and Robotics
- **Study Level**: First-cycle (Engineer) programme
- **Form of Study**: Full-time studies
- **Profile**: General academic
- **Didactic Cycle**: 2021/2022
- **Course Code**: RIAKS.Ii10PJO.02553.21
- **Lecture Language**: English
- **Mandatoriness**: Obligatory
- **Block**: Elective Modules in Foreign Language
- **Course Related to Scientific Research**: Yes
- **Course Coordinator**: Piotr Kleczkowski
- **Lecturers**: Piotr Kleczkowski, Dorota Młynarczyk, Jacek Wierzbicki, Katarzyna Kotarba
- **Period**: Semester 5
- **Method of Verification of Learning Outcomes**: Exam

Course Structure

- **Lectures**: 42 hours
- **Laboratory Classes**: 42 hours
- **ECTS Credits**: 10

Learning Goals

The goal of the course is to provide students with the basic knowledge of audio engineering. This includes:

- The fundamentals of signal and system theory
- Basic parameters of audio equipment, their relation to human perception, and methods of measurement

- Introduction to digital audio technology and basic operational principles of audio equipment and systems

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Learning Outcomes

Upon completing the course, students will be able to:

- **Knowledge**:
    - **W1**: Understand basic parameters of audio equipment and their relation to human perception, along with methods of measurement.
    - **W2**: Know about devices and software used in audio engineering and how to set up systems.
    - **W3**: Understand methods of recording audio signals and reproduction systems.
- **Skills**:
    - **U1**: Use audio engineering equipment, set up systems, perform audio recording, and process it.
    - **U2**: Evaluate the quality of audio devices, systems, and materials.
- **Social Competencies**:
    - **K1**: Communicate efficiently with professionals in the field in both English and Polish.

Course Content

1. **Lectures**:
    - Introduction to subjective and objective audio quality, key audio parameters, and common myths in the field.
    - Basics of signal and system theory.
    - The decibel scale and its applications.
    - Audio metering and key parameters like frequency response, distortion, and noise.
    - Overview of analog mixing consoles and microphones.
    - Signal processing techniques: filters, equalizers, dynamic range processors, time-based effects.
    - Introduction to digital audio and sound reproduction systems.
2. **Laboratory Classes**:

    - Practical exercises on cables, connectors, and measurement equipment.
    - Hands-on work with analog mixing consoles and microphone techniques.
    - Audio signal processing using equalizers and dynamic range processors.
    - Measurements of frequency response and nonlinear distortion with professional systems.
    - Design of active monitors with digital crossovers and working with hardware effects (e.g., Focusrite VoiceMaster and ISA 430).
    - Stereo techniques and monitoring practices.

Teaching Methods:

- Lectures
- Discussions
- Group work
- Project-based learning

Student Workload:

- **Lectures**: 42 hours
- **Laboratory Classes**: 42 hours
- **Preparation for Classes**: 84 hours
- **Independent Task Completion**: 40 hours
- **Examination or Final Test**: 2 hours
- **Project/Report Preparation**: 40 hours
- **Total**: 250 hours

Literature:

Obligatory:

1. Ballou, G. *Handbook for Sound Engineers*, Taylor & Francis, 2015
2. Davis, D., Patronis, E. *Sound System Engineering*, Focal Press, 2006
3. Rumsey, F., McCormick, T. *Sound and Recording*, Focal Press, 2009
4. Huber, D. M., Runstein, R. E. *Modern Recording Techniques*, Focal Press, 2014

5. Owsiński, B. *The Recording Engineer's Handbook*, Cengage Learning, 2014
6. Rayburn, R. A. *Eargle's Microphone Book*, Focal Press, 2013
7. Toole, F. L. *Sound Reproduction*, Taylor & Francis, 2017
8. Newell, P., Holland, K. *Loudspeakers: For Music Recording and Reproduction*, Focal Press, 2013
9. Roginska, A., Geluso, P. *Immersive Sound*, Routledge, 2018
10. Sztekmiler, K. *Podstawy Nagłośnienia i Realizacji Nagrań*, WKŁ, 2011
11. Kleczkowski, P. *Percepcja Dźwięku*, Wydawnictwa AGH, 2013
12. Winer, E. *The Audio Expert*, Focal Press, 2013
13. Leśniewicz, M. *Domowe Systemy Audio*, Wydawnictwo btc, 2014
14. Self, D., et al. *Audio Engineering – Know It All*, Elsevier, 2009

Musical Acoustics

- **Field of Study**: Acoustic Engineering
- **Organisational Unit**: Faculty of Mechanical Engineering and Robotics
- **Study Level**: First-cycle (Engineer) programme
- **Form of Study**: Full-time studies
- **Profile**: General academic
- **Didactic Cycle**: 2021/2022
- **Course Code**: RIAKS.Ii10K.02555.21
- **Lecture Language**: Polish
- **Mandatoriness**: Elective
- **Block**: Core Modules
- **Course Related to Scientific Research**: Yes
- **Course Coordinator**: Marek Pluta
- **Lecturers**: Marek Pluta, Adam Pilch
- **Period**: Semester 5
- **Method of Verification of Learning Outcomes**: Completing the classes

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Course Structure

- **Lectures**: 39 hours
- **Laboratory Classes**: 26 hours
- **ECTS Credits**: 6

Learning Goals

The goal of the course is to provide students with knowledge about the production of sound in musical instruments and to familiarize them with various acoustical phenomena related to music. This includes:

- Understanding the acoustical properties of musical instruments
- Studying different musical instrument groups and their sound characteristics
- Conducting practical experiments and measurements related to musical acoustics

Learning Outcomes

Upon completing the course, students will be able to:

- **Knowledge**:
    - **W1**: Understand the basic structure and sound production mechanisms of musical instruments, as well as their directional characteristics.
    - **W2**: Know the composition and arrangement of musicians in classical and popular music ensembles.
- **Skills**:
    - **U1**: Generate and analyze phenomena associated with sound production in musical instruments.
    - **U2**: Recognize acoustical phenomena related to sound production in musical instruments.
- **Social Competencies**:
    - **K1**: Efficiently combine musical terminology with sound engineering terminology.

Course Content

1. **Lectures**:
    - Pitch of Sound
    - Tuning and sound systems. Combination tones
    - Acoustic resolution in the frequency domain
    - Timbre of sound. Analysis of the auditory scene
    - Observation of combination tones
    - Classification of instruments. String instruments
    - Observation of the effect of damping on perceived roughness
    - Bowed string instruments – violins
    - Sound registration of strings
    - Other bowed string instruments
    - String sound analysis
    - Percussion string instruments – piano

    - Sound registration of string instruments
    - Plucked and struck string instruments – clavichord, harpsichord, harp, guitar
    - Sound analysis of string instruments
    - Organ pipes. Organ acoustics
    - Aerophones (wind instruments)
    - Spectral analysis of wind instruments
    - Idiophones and membranophones
    - Sound registration and analysis of selected idiophones and membranophones
    - Electrophones (electronic instruments)
    - Sound registration and analysis of selected electrophones
    - MIR (Musical Instrument Registration). Instrument arrangements in ensembles
2. **Laboratory Classes**:
    - Conducting experiments on various sound production phenomena related to musical instruments
    - Sound analysis and measurements of various musical instruments and their components
    - Registration and analysis of different instruments' sounds
    - Execution of laboratory tasks based on instrument groups like string, percussion, and wind instruments

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Teaching Methods:

- Lectures
- Discussions
- Laboratory work and practical tasks

Student Workload:

- **Lectures**: 39 hours
- **Laboratory Classes**: 26 hours
- **Preparation for Classes**: 26 hours
- **Independent Task Completion**: 39 hours
- **Project/Report Preparation**: 26 hours

- **Total**: 156 hours

Literature:

Obligatory:

1. Benade, A.H. *Fundamentals of Musical Acoustics (2nd ed.)*. Dover Publications, 1990
2. Moore, B.C.J. *Wprowadzenie do psychologii słyszenia*. PWN, 1999
3. Ozimek, E. *Dźwięk i jego percepcja*. PWN, 2002
4. Drobner, M. *Instrumentoznawstwo i akustyka*. PWM, 2004

Optional:

1. Rakowski, A. *Studia nad wysokością i barwą dźwięku w muzyce*. Wyd. Akad. Muzycznej im. Fryderyka Chopina, 1999

Principles of Machine Learning in Acoustical Technologies

Basic Information
• **Field of Study**: Acoustic Engineering
• **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
• **Study Level**: First-cycle (Engineer) Programme
• **Form of Study**: Full-time Studies
• **Profile**: General Academic
• **Didactic Cycle**: 2021/2022
• **Course Code**: RIAKS.Ii10O.12355.21
• **Lecture Languages**: Polish
• **Mandatoriness**: Elective
• **Block**: General Modules
• **Course Related to Scientific Research**: Yes
• **Course Coordinator**: Piotr Kleczkowski
• **Lecturers**: Katarzyna Kotarba, Aleksandra Król-Nowak, Marek Pluta
• **Period**: Semester 5

Activities and Hours
• **Lectures**: 39 hours
• **Laboratory Classes**: 18 hours
• **Project Classes**: 12 hours
• **Number of ECTS Credits**: 6

Course Goals
• C1: Introduce students to machine learning algorithms applied in acoustical technologies.

Learning Outcomes
Knowledge:
• W1: Understands machine learning algorithms used in acoustical technologies.
• W2: Familiar with tools applied in acoustical technologies utilizing machine learning algorithms.

Skills:
• U1: Able to select and apply an appropriate machine learning algorithm to solve acoustical technology problems.
• U2: Able to implement and verify the operation of a machine learning algorithm in acoustical applications.

Social Competences:
• K1: Able to solve complex problems combining acoustical knowledge with machine learning techniques.

Program Content

1. **Introduction to Machine Learning**
   • Classification of algorithms, success metrics, k-nearest neighbors method.
   • Data processing and preparation, dimensionality reduction.
   • PCA, ICA.
2. **Unsupervised Learning**
   • k-means algorithm, Gaussian Mixture Model (GMM), clustering.
3. **Linear Models**
   • Logistic regression, Support Vector Machines (SVM).
4. **Decision Trees and Random Forests**
   • Classification trees, Random Forests, Gradient Boosting Algorithm.
5. **Neural Networks**
   • Introduction to neural networks, architecture, and applications.
6. **Genetic Algorithms**
   • Genetic algorithms in machine learning applications.
7. **Reinforcement Learning**
   • Basic concepts of reinforcement learning.
8. **Machine Learning in Acoustic Signal Analysis**
   • Application of machine learning in analyzing instrument and music recordings.
9. **Machine Learning in Music Production**
   • Generation, effects, mixing, and mastering using machine learning.

Laboratory Classes
• Introduction to Python programming, scikit-learn, and matplotlib for data visualization.
• Dimensionality reduction, PCA, ICA.
• Sound source separation with PCA and ICA.
• Clustering algorithms for music analysis.
• Acoustic signal classification using SVM.
• Random Forests, Gradient Boosting (LightGBM, XGBoost).
• Introduction to PyTorch.
• Neural network applications in acoustic diagnostics.
• Machine learning in music recordings analysis.

Project Classes
• **Project 1**: Topic selection, feature extraction, algorithm selection and implementation, results analysis, and project presentation.

• **Project 2**: Machine learning in music production (generation, effects, mixing, mastering). Selection of tools and algorithm, implementation, and project verification.

Student Workload
• **Lectures**: 39 hours
• **Laboratory Classes**: 18 hours
• **Project Classes**: 12 hours
• **Independent Work**: 39 hours
• **Preparation for Project and Reports**: 45 hours
• **Total Workload**: 153 hours
• **Teacher Workload**: 69 hours

Teaching Methods
Lectures, Laboratory Work, Group Discussions

Literature
Obligatory

1. A. Courville, I. Goodfellow, Y. Bengio – *Deep Learning: Współczesne systemy uczące się*, PWN, 2020
2. A. Geron – *Uczenie maszynowe z użyciem Scikit-Learn i TensorFlow*, Helion, 2020
3. C. M. Bishop – *Pattern Recognition and Machine Learning*, Springer, 2011

Optional

1. C. Liu, C. Ting – "Computational Intelligence in Music Composition: A Survey," IEEE Transactions on Emerging Topics in Computational Intelligence, 2017
2. A. Alpern – "Techniques for Algorithmic Composition of Music", 1995

Audio Mixing Engineering

Basic Information
- **Field of Study:** Acoustic Engineering
- **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
- **Study Level:** First-cycle (Engineer) Programme
- **Form of Study:** Full-time Studies
- **Profile:** General Academic
- **Didactic Cycle:** 2021/2022
- **Course Code:** RIAKS.Ii20K.02599.21
- **Lecture Languages:** Polish
- **Mandatoriness:** Elective
- **Block:** Core Modules
- **Course Related to Scientific Research:** Yes
- **Course Coordinator:** Paweł Małecki
- **Lecturer:** Paweł Małecki
- **Period:** Semester 6
- **Method of Verification of Learning Outcomes:** Exam

Activities and Hours
- **Lectures:** 28 hours
- **Laboratory Classes:** 56 hours
- **Number of ECTS Credits:** 6

Course's Learning Outcomes

Knowledge – Student knows and understands:
- **W1:** Knows the elements of the mixing process and the tools used in it.
Verification: Test, Project, Examination

Skills – Student can:
- **U1:** Can recognize fundamental musical phenomena by ear.
Verification: Activity during classes, Execution of laboratory classes, Examination, Test results
- **U2:** Can correctly perform audio production to meet current commercial standards.
Verification: Project
- **U3:** Can consciously shape the sound of a music production.
Verification: Activity during classes, Project

Student Workload
- **Lectures:** 28 hours
- **Laboratory Classes:** 56 hours

• **Preparation for Classes:** 35 hours
• **Realization of Independently Performed Tasks:** 24 hours
• **Examination or Final Test/Colloquium:** 2 hours
• **Contact Hours:** 5 hours

Total Student Workload: 150 hours
Teacher Workload: 84 hours

Program Content

1. Basics of mixing (Lectures)
2. Basic principles of the mixing process: Overview of the workspace used in the mixing process. Understanding the stages of music production. (Laboratory Classes)
3. Shaping the stereophonic space using ILD and ITD mechanisms. (Laboratory Classes)
4. Stereo space and basic tools for sound recording. (Lectures)
5. Shaping the timbre of music signals using equalizers. (Laboratory Classes)
6. Acoustics of a recording studio. (Lectures)
7. Tone correction. (Lectures)
8. Using dynamic processors in sound creation: Working with various sound signals using typical dynamic processors: compressor, limiter, gate, expander. (Laboratory Classes)
9. Voice recording. (Laboratory Classes)
10. Dynamic processors part 1 (compressor, limiter). (Lectures)
11. Creating space in the mix using reverb processors. (Laboratory Classes)
12. Dynamic processors part 2 (expander, gate). (Lectures)
13. Using delay lines and modulation effects in shaping timbre. (Laboratory Classes)
14. Dynamic processors part 3 (ducker) / Overdrive effects. (Lectures)
15. Delay lines, modulation, and frequency effects. (Lectures)
16. Using automation to achieve greater "musicality" and special effects in music production. (Laboratory Classes)
17. Finalizing the mix using alternative listening systems. (Laboratory Classes)
18. Automation in audio. (Lectures)
19. Auditory assessment of final projects. (Laboratory Classes)
20. Standardization in sound production. (Lectures)
21. Recording and shaping vocal tracks. (Lectures)

22. Recording and shaping the sound of individual musical instruments. (Lectures)

Teaching Methods and Techniques
Lectures, Project-based learning

Activities
• **Lectures:** Activity during classes, Execution of laboratory classes, Test, Project, Examination, Test results.
• **Laboratory Classes:** Activity during classes, Execution of laboratory classes, Examination, Test results.

Rules of Participation in Classes:

- **Lectures:** Students participate in lectures to acquire knowledge in line with the syllabus. They are encouraged to ask questions and clarify any doubts. Audiovisual recording of the lecture requires the instructor's consent.
- **Laboratory Classes:** Students perform laboratory exercises following the materials provided by the instructor. Preparation for the exercise may be assessed through oral or written quizzes. The completion of all laboratory exercises is required to pass the module.
- **Project Classes:** Students work on practical tasks to achieve the competencies defined in the syllabus. Evaluation will focus on the project execution and the final result.

Literature
Obligatory:

1. Roey Izhaki, *Mixing Audio: Concepts, Practices and Tools*, Focal Press, 2011
2. Alex Case, *Mix Smart: Pro Audio Tips For Your Multitrack Mix*, Focal Press, 2011
3. Bobby Owsinski, *The Mixing Engineering Handbook*, Course Technology, 2014
4. Bob Katz, *Mastering Audio: The Art and the Science*, Focal Press, 2007
5. Closed-back studio quality headphones
6. Personal computer with DAW software

Live Sound Engineering

Basic Information
• **Field of Study:** Acoustic Engineering
• **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
• **Study Level:** First-cycle (Engineer) Programme
• **Form of Study:** Full-time Studies
• **Profile:** General Academic
• **Didactic Cycle:** 2021/2022
• **Course Code:** RIAKS.Ii20K.07789.21
• **Lecture Languages:** Polish
• **Mandatoriness:** Elective
• **Block:** Core Modules
• **Course Related to Scientific Research:** Yes
• **Course Coordinator:** Paweł Małecki
• **Lecturer:** Paweł Małecki
• **Period:** Semester 6
• **Method of Verification of Learning Outcomes:** Completing the Classes

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Activities and Hours
• **Laboratory Classes:** 28 hours
• **Number of ECTS Credits:** 2

Goals
• **C1:** Introduction to the elements of the electroacoustic path used in live sound productions.
• **C2:** Providing knowledge on configuring electroacoustic paths in sound amplification systems.
• **C3:** Familiarizing students with the stages of working with sound systems.
• **C4:** Raising awareness of the specifics of Front of House (FOH) and monitor sound systems.

Course's Learning Outcomes

Knowledge – Student knows and understands:
• **W1:** Elements of the electroacoustic path used in live sound productions.
Verification: Activity during classes, Execution of exercises, Test
• **W2:** Basic approaches and differences in FOH sound and monitor sound system implementations.
Verification: Activity during classes, Execution of exercises, Test

Skills – Student can:
• **U1:** Configure the electroacoustic path.
Verification: Activity during classes, Execution of exercises, Test

• **U2:** Conduct a sound check with a music band.
Verification: Activity during classes, Execution of exercises

Social Competences – Student is ready to:
• **K1:** Work with musicians, artists, and music performers.
Verification: Activity during classes, Execution of exercises

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Student Workload
• **Laboratory Classes:** 28 hours
• **Preparation for Classes:** 12 hours
• **Realization of Independently Performed Tasks:** 12 hours
• **Contact Hours:** 5 hours

Total Student Workload: 57 hours
Teacher Workload: 28 hours

Program Content

1. Basics of operating digital consoles – delay sections, other effects, and reverbs: Practical exercises with digital consoles.

2. Basics of operating analog consoles: Practical exercises with the operation and configuration of analog consoles.

3. Basics of operating digital consoles – routing: Practical exercises with digital console configuration.

4. Basics of operating digital consoles – equalizer and dynamics sections: Practical exercises with digital consoles.

5. Implementing monitor sound system: Practical exercises with performing the required number of signal paths for monitoring.

Teaching Methods and Techniques
• Discussion
• Group work

Activities
• **Laboratory Classes:** Activity during classes, Execution of exercises, Test

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Literature
Obligatory:

1. *Mixing Audio, Second Edition: Concepts, Practices and Tools* by Roey Izhaki, Focal Press, 2nd Edition

2. *Live Sound Reinforcement (Mix Pro Audio Series)* by Scott Hunter Stark
3. *Principles of Digital Audio, Sixth Edition* by Ken C. Pohlmann

Optional:

1. *The Mixing Engineer's Handbook, 4th Edition* by Bobby Owsinski, Bobby Owsinski Media Group

Methods and Software Tools in Acoustics

Basic Information
• **Field of Study:** Acoustic Engineering
• **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
• **Study Level:** First-cycle (Engineer) Programme
• **Form of Study:** Full-time Studies
• **Profile:** General Academic
• **Didactic Cycle:** 2021/2022
• **Course Code:** RIAKS.Ii20K.02604.21
• **Lecture Languages:** Polish
• **Mandatoriness:** Elective
• **Block:** Core Modules
• **Course Related to Scientific Research:** Yes
• **Course Coordinator:** Ryszard Olszewski
• **Lecturers:** Ryszard Olszewski, Bartłomiej Borkowski, Krzysztof Kosała, Ireneusz Czajka, Katarzyna Suder-Dębska
• **Period:** Semester 6
• **Method of Verification of Learning Outcomes:** Completing the Classes

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Activities and Hours
• **Lectures:** 14 hours
• **Laboratory Classes:** 26 hours
• **Project Classes:** 10 hours
• **Number of ECTS Credits:** 4

Goals
• **C1:** Introduction to contemporary methods of acoustic field analysis for room acoustics and environmental acoustics using available software tools.

Course's Learning Outcomes

Knowledge – Student knows and understands:
• **W1:** The methods for modeling acoustic fields, as well as basic numerical models of fields and acoustic systems.
Verification: Activity during classes, Execution of laboratory classes, Test, Project, Completion of laboratory classes
• **W2:** Knowledge of the methodology and software techniques for analyzing acoustic fields in both open and enclosed spaces, and principles of shaping acoustic parameters of interiors.
Verification: Execution of a project, Test, Project, Report

Skills – Student can:
• **U1:** Classify a given task in terms of selecting the appropriate method for problem analysis.
Verification: Execution of laboratory classes, Test, Report
• **U2:** Appropriately use selected environments and computer-aided design tools for simulating, designing, and verifying acoustic systems.
Verification: Project, Report
• **U3:** Build a numerical model, identify basic properties of modeled systems, and conduct numerical analysis.
Verification: Execution of laboratory classes, Test, Report
• **U4:** Develop documentation regarding the task, create drawings, diagrams, and prepare a summary text.
Verification: Project

Social Competences – Student is ready to:
• **K1:** Effectively work both independently and in teams, utilizing the results of others' work.
Verification: Activity during classes, Execution of a project

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Student Workload
• **Lectures:** 14 hours
• **Laboratory Classes:** 26 hours
• **Project Classes:** 10 hours
• **Preparation for Classes:** 19 hours
• **Realization of Independently Performed Tasks:** 6 hours
• **Contact Hours:** 5 hours
• **Preparation of Project, Presentation, Essay, Report:** 30 hours

Total Student Workload: 110 hours
Teacher Workload: 50 hours

Program Content

1. Basic concepts and formulations of numerical acoustic field analysis.
   Methods for geometric analysis of the acoustic field.
   Finite Difference Method (FDM).
   Finite Element Method (FEM).
   Boundary Element Method (BEM).
   Statistical Energy Analysis (SEA).
   Hybrid methods.
   Activities: Lectures

2. Basics of building acoustic system geometry models.
   Geometric methods.
   Finite Element Method (FEM) and Boundary Element Method (BEM).
   Modeling physical absorption coefficients of sound.

Modeling acoustic effectiveness of soundproofing-insulation enclosures.
Methods for simulating acoustic fields in unbounded spaces.
Activities: Laboratory Classes

3. Execution of an individual project according to the assigned task for one of the methods of acoustic field analysis.
   Execution of a group project.
   Activities: Project Classes

Teaching Methods and Techniques
• Lectures

Activities
• **Lectures:** Activity during classes, Execution of a project, Execution of laboratory classes, Test, Project, Report, Completion of laboratory classes
• **Laboratory Classes:** Activity during classes, Execution of a project, Execution of laboratory classes, Test, Project, Report, Completion of laboratory classes
• **Project Classes:** Activity during classes, Execution of a project, Execution of laboratory classes, Test, Project, Report

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Literature
Obligatory:

1. Ciskowski R.D., Brebbia C.A.: *Boundary Element Methods in Acoustics*, Elsevier Applied Science, London, 1991.
2. Gołaś A.: *Metody komputerowe w akustyce wnętrz i środowiska*, Wyd. AGH, Kraków, 1995.
3. Kincaid D., Cheney W.: *Analiza numeryczna*, WNT, Warszawa, 2006.
4. Ziemiański L.: *Metoda elementów skończonych w analizie procesów wibroakustycznych*, Oficyna Wydawnicza Politechniki Rzeszowskiej, Rzeszów, 1997.
5. Zienkiewicz O.C.: *Metoda elementów skończonych*, Arkady, Warszawa, 1972.

Multimedia Techniques

Basic Information
- **Field of Study:** Acoustic Engineering
- **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
- **Study Level:** First-cycle (Engineer) Programme
- **Form of Study:** Full-time Studies
- **Profile:** General Academic
- **Didactic Cycle:** 2021/2022
- **Course Code:** RIAKS.Ii20K.01504.21
- **Lecture Languages:** Polish
- **Mandatoriness:** Elective
- **Block:** Core Modules
- **Course Related to Scientific Research:** No
- **Course Coordinator:** Stanisław Kacprzak
- **Lecturer:** Stanisław Kacprzak
- **Period:** Semester 6
- **Method of Verification of Learning Outcomes:** Completing the Classes

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Activities and Hours
- **Lectures:** 14 hours
- **Project Classes:** 14 hours
- **Number of ECTS Credits:** 2

Course's Learning Outcomes

Knowledge – Student knows and understands:
- **W1:** Knowledge of the basic principles of multimedia communication, understanding of coding and compression principles for speech and audio, as well as processing of images and video sequences.
Verification: Execution of a project
- **W2:** Knowledge of modern multimedia transmission systems in computer networks and the Internet.
Verification: Execution of a project
- **W3:** Knowledge of protocols supporting multimedia transmission in the Internet network.
Verification: Execution of a project

Skills – Student can:
- **U1:** Ability to create and process computer graphics using professional image processing software.
Verification: Execution of a project
- **U2:** Ability to create multimedia elements for websites and embed multimedia objects on web

pages.
Verification: Execution of a project
• **U3:** Ability to create simple computer animations.
Verification: Execution of a project

Social Competences – Student is ready to:
• **K1:** Ability to work in a team of designers, performing a designated part of the project task according to the established assumptions.
Verification: Execution of a project
• **K2:** Understanding the need for and knowing the possibilities of continuous self-education and improving professional competencies.
Verification: Execution of a project
• **K3:** Awareness of the importance of maintaining professionalism, ability to write a report from the engineering task in a clear and responsible manner.
Verification: Execution of a project

Student Workload
• **Lectures:** 14 hours
• **Project Classes:** 14 hours
• **Realization of Independently Performed Tasks:** 25 hours
• **Contact Hours:** 5 hours
• **Preparation of Project, Presentation, Essay, Report:** 2 hours

Total Student Workload: 60 hours
Workload Involving Teacher: 28 hours

Program Content

1. Introduction to multimedia concepts.
   Activities: Lectures

2. Text as the basic medium, basics of typography.
   Activities: Lectures

3. Basics of computer graphics (vector graphics, raster graphics).
   Activities: Lectures

4. Video sequences and computer animation.
   Activities: Lectures, Project classes

5. Creating websites – HTML, CSS. Content Management Systems (CMS).
   Activities: Lectures, Project classes

6. Basic data transmission protocols.
   Activities: Lectures

7. Examples of multimedia systems and virtual reality.
   Activities: Lectures

8. Creating a website using a content management system with multimedia content:

   - Vector graphics (interactive SVG)
   - Raster graphics (photomontage, retouching)
   - Audio/video editing (music video editing)
   - Scene/3D animation
     Activities: Project classes

Teaching Methods and Techniques
• E-learning
• Peer assessment
• Lectures

Activities
• **Lectures:** Execution of a project
• **Project Classes:** Execution of a project

Literature
Obligatory:

1. *Cyfrowe przetwarzanie sygnałów w telekomunikacji: podstawy, multimedia, transmisja* / ed. Tomasz P. Zieliński, Przemysław Korohoda, Roman Rumian. Warsaw: PWN Scientific Publishers, 2014.

Practical Placement

Basic Information
• **Field of Study:** Acoustic Engineering
• **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
• **Study Level:** First-cycle (Engineer) Programme
• **Form of Study:** Full-time Studies
• **Profile:** General Academic
• **Didactic Cycle:** 2021/2022
• **Course Code:** RIAKS.Ii20K.00035.21
• **Lecture Languages:** Polish
• **Mandatoriness:** Obligatory
• **Block:** Core Modules
• **Course Related to Scientific Research:** No
• **Course Coordinator:** Radosław Marczuk
• **Lecturer:** Radosław Marczuk
• **Period:** Semester 6
• **Method of Verification of Learning Outcomes:** Completing the Classes

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Activities and Hours
• **Practical Placement:** 100 hours
• **Number of ECTS Credits:** 4

Course's Learning Outcomes

Knowledge – Student knows and understands:
• **W1:** Knows the safety and hygiene rules applicable at the workplace and similar workplaces.
Verification: Report on completion of a practical placement, Confirmation of completion of practical placement programme
• **W2:** Learns the working conditions, their progression over daily, weekly, or monthly cycles, and typical problems associated with work in the observed workplace and similar environments.
Verification: Report on completion of a practical placement, Confirmation of completion of practical placement programme

Skills – Student can:
• **U1:** Able to independently or in a team carry out basic engineering tasks.
Verification: Report on completion of a practical placement, Confirmation of completion of practical placement programme
• **U2:** Able to estimate the time needed to complete a task, prepare and execute a work schedule ensuring deadlines are met.
Verification: Report on completion of a practical placement, Confirmation of completion of practical placement programme

Social Competences – Student is ready to:
• **K1:** Able to work both in a team and individually, effectively communicate with superiors and other team members, and acquire practical knowledge from other team members.
Verification: Report on completion of a practical placement, Confirmation of completion of practical placement programme

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Student Workload
• **Realization of Independently Performed Tasks:** 100 hours

Total Student Workload: 100 hours

Program Content

1. Practical placement.
   Course's Learning Outcomes: W1, W2, U1, U2, K1
   Activities: Practical placement

Teaching Methods and Techniques
• Teaching methods and techniques used at the place where the practical placement is performed.

Activities
• **Practical Placement:**
Verification: Report on completion of a practical placement, Confirmation of completion of practical placement programme

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Literature
Obligatory:

1. Not applicable

Sound Absorption and Dispersion Technology

Basic information

- **Field of study:** Acoustic Engineering
- **Major:** -
- **Organisational unit:** Faculty of Mechanical Engineering and Robotics
- **Study level:** First-cycle (engineer) programme
- **Form of study:** Full-time studies
- **Profile:** General academic
- **Didactic cycle:** 2021/2022
- **Course code:** RIAKS.Ii20K.02614.21
- **Lecture languages:** Polish
- **Mandatoriness:** Elective
- **Block:** Core Modules
- **Course related to scientific research:** Yes
- **Course coordinator:** Adam Pilch
- **Lecturer:** Adam Pilch, Tadeusz Kamisiński, Jarosław Rubacha, Artur Flach
- **Period:** Semester 6
- **Method of verification of the learning outcomes:** Completing the classes

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- **Activities and hours:**
  - Lectures: 12
  - Laboratory classes: 14
  - Project classes: 20
- **Number of ECTS credits:** 4

Goals

- **C1:** The module aims to provide students with knowledge and skills related to the modeling, measurement, and application of sound-absorbing and diffusive elements used in room acoustics

Course's learning outcomes

- **Knowledge – Student knows and understands:**
  - **W1:** Defines acoustic parameters of diffusive elements (IAK1A_W05, IAK1A_W08, IAK1A_W19)
  - **W2:** Analyzes the acoustic parameters of sound-absorbing elements (IAK1A_W12)
  - **W3:** Knows models describing sound absorption in porous and fibrous materials (IAK1A_W04, IAK1A_W06)
  - **W4:** Knows methods for measuring the quantities describing sound absorption and diffusion by acoustic elements (IAK1A_W06, IAK1A_W12)
  - **W5:** Knows models describing sound absorption in resonant elements (IAK1A_W04, IAK1A_W06)
- **Skills – Student can:**
  - **U1:** Consciously applies acoustic materials and elements in room acoustic adaptations (IAK1A_U01, IAK1A_U20, IAK1A_U26)
  - **U2:** Designs diffusive elements with specific parameters (IAK1A_U01, IAK1A_U09)
  - **U3:** Can determine sound absorption characteristics for resonant elements based on theoretical models (IAK1A_U01, IAK1A_U08, IAK1A_U09, IAK1A_U11)
  - **U4:** Can determine sound absorption characteristics for porous and fibrous materials based on theoretical models (IAK1A_U01, IAK1A_U09, IAK1A_U17)
- **Social competences – Student is ready to:**
  - **K1:** Can collaborate with other industries (architects, designers) in the design of acoustic elements (IAK1A_K01)

Student workload

- **Activity form | Average amount of hours**
  - Lectures: 12
  - Laboratory classes: 14
  - Project classes: 20
  - Preparation for classes: 17
  - Examination or final test/colloquium: 2
  - Contact hours: 5

- Preparation of project, presentation, essay, report: 30

Total Student workload: 100
Workload involving teacher: 46

(* hour means 45 minutes)

Program content

1. **Sound absorption phenomena in materials and measurement methods**
    - Basics of sound absorption physics, reflection coefficient, impedance, sound absorption coefficient.
    - Measurement using impedance tube, reverberation chamber, impedance method.
2. **Sound absorption in porous and fibrous materials**
    - Quantities describing acoustic phenomena in porous and fibrous materials - definitions and measurement.
    - Sound absorption models in fibrous materials.
    - Types of porous and fibrous materials, typical sound absorption characteristics, applications.
3. **Resonant elements**
    - Construction and characteristic quantities of plate, perforated, slot, and microperforated elements.
    - Sound absorption models for resonant elements, examples of commercial solutions, applications.
4. **Sound diffusion elements**
    - Phenomenon of sound diffusion - definition, measurement.
    - Construction of sound diffusive elements, basic design formulas, applications.
5. **Prediction of sound absorption and diffusion by diffusive elements**
    - Models of sound absorption by diffusive elements, models of sound diffusion by diffusive elements.
    - Pseudorandom sequences used in designing diffusive elements, design and application issues.
6. **Application of acoustic elements in small room acoustics**
    - Small room acoustics issues, concepts of acoustic adaptation (LEDE, RFZ, etc.).
    - Reduction of acoustic defects in small rooms using acoustic elements.

7. **Laboratory Classes**
    - **Sound absorption coefficient measurement by impedance method**
    - **Influence of mounting and finishing on acoustic properties**
    - **Measurement of absorption coefficient of resonant elements in anechoic chamber**
    - **Effect of placement of acoustic elements on room acoustics**
    - **Sound diffusion coefficient measurements (ISO 17497-2, ISO 17497-1)**
8. **Project Classes**
    - **Impulse response system (Matlab)**
    - **Modeling multilayer structure (Mineral wool, Matlab)**
    - **Modeling of reverberation sound absorption coefficient (Matlab)**
    - **Resonant element sound absorption modeling (Matlab)**
    - **Designing reflective panel systems (Matlab)**
    - **Numerical modeling of diffusive elements (Matlab)**
    - **Determining sound diffusion coefficient from measurements (Matlab)**
    - **Technical documentation (AutoCAD)**
    - **Optimization of diffusive elements (Matlab)**
    - **Room acoustic adaptation project (Catt Acoustic)**

Teaching methods and techniques:
Lectures, Case study, Group work, Problem-based learning, Gamification

Activities:

- **Lectures:** Activity during classes, Participation in a discussion, Case study
- **Laboratory classes:** Activity during classes, Participation in a discussion, Report, Case study, Teamwork
- **Project classes:** Activity during classes, Project, Teamwork

Literature

- **Obligatory:**
    1. Cox T., *Acoustic Absorbers and Diffusers: Theory, Design and Application*, Taylor & Francis, 2009

2. Allard J., *Propagation of Sound in Porous Media: Modelling Sound Absorbing Materials*, John Wiley & Sons, 2009

3. Kuttruff H., *Room Acoustics*, Taylor & Francis, London 2009

- **Optional:**

    1. Kulowski A., *Akustyka Sal*, Wydawnictwo PG, Gdańsk, 2011

    2. Makarewicz R., *Wstęp do Akustyki Teoretycznej*, Wydawnictwo UAM, Poznań, 2005

Universalism of Mathematical Modeling

Basic Information
• **Field of Study:** Acoustic Engineering
• **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
• **Study Level:** First-cycle (Engineer) Programme
• **Form of Study:** Full-time Studies
• **Profile:** General Academic
• **Didactic Cycle:** 2021/2022
• **Course Code:** RIAKS.Ii20K.02606.21
• **Lecture Languages:** Polish
• **Mandatoriness:** Obligatory
• **Block:** Core Modules
• **Course Related to Scientific Research:** Yes
• **Course Coordinator:** Aleksandra Król-Nowak
• **Lecturer:** Aleksandra Król-Nowak
• **Period:** Semester 6
• **Method of Verification of Learning Outcomes:** Exam

Activities and Hours
• **Lectures:** 14 hours
• **Seminars:** 13 hours
• **Number of ECTS Credits:** 4

Course Goals
• **C1:** Introduce students to the universality of the mathematical description of the physical world.
• **C2:** Provide knowledge on the universality of mathematical modeling using analytical and numerical methods.

Course's Learning Outcomes
Knowledge:
• **W1:** Understands the interdisciplinary nature of acoustics and its connection with other scientific fields, knows the acoustic-mechanical-electrical analogies, and understands the applications of acoustics in diagnostics, medicine, and other fields.
Skills:
• **U1:** Can apply basic physical concepts and the principle of universality in mathematical solutions to describe real acoustic, mechanical, and electrical systems and select the appropriate model for system analysis. Can integrate knowledge from various fields, including acoustics, electronics, computer science, and mechanics, while solving problems related to

modeling and designing acoustic systems, devices, and software.
• **U2:** Can recognize the most appropriate mathematical model for describing real acoustic fields or systems among the available mathematical models.
Social Competences:
• **K1:** Aware of the limitations of their knowledge and the necessity to continuously enhance professional and social competencies.

Student Workload
• **Lectures:** 14 hours
• **Seminars:** 13 hours
• **Independent Tasks:** 35 hours
• **Contact Hours:** 5 hours
• **Project/Presentation/Essay/Report Preparation:** 32 hours
• **Examination or Final Test:** 2 hours
• **Total Workload:** 101 hours
• **Teacher Workload:** 27 hours

Program Content

1. **Mathematics as a Universal Tool for Describing the Physical World**
   • The interdisciplinary nature of acoustics as a field at the intersection of natural sciences (physical acoustics, electroacoustics, structural acoustics), humanities (speech acoustics, psychoacoustics), and art (musical and architectural acoustics).
   • The basic equations of physical acoustics as an example of nonlinear equations.
   • The usefulness and universality of linear theories and examples of linear mathematical structures.
   • Linearization of fundamental acoustic equations derived from first principles.
   • Acoustic systems with lumped parameters—acoustic-mechanical-electrical analogies.
   • Description of mechanical, acoustic, and electrical systems via impedance—acoustic and electrical filters.
   • Acoustic systems with distributed parameters—acoustic and electromagnetic waveguides—analogies.
   • New discoveries predicted by mathematical theories (e.g., gravitational waves).
   • The artificial intelligence problem.
   • Numerical programs for studying acoustic fields (AcTran - Acoustic Transmission, Ansys, COMSOL Multiphysics, etc.).
   • Cyfronet - AGH Computer Center—important projects, access for staff and students.
   • Metamaterials—electromagnetic and acoustic.
   • New applications of number theory, including cryptography.
   • Catastrophes as a result of poor mathematical modeling.

Teaching Methods
Lectures, Discussions

Activities and Methods of Verification
• **Lectures:** Activity during classes, participation in discussions, examination.
• **Seminar Classes:** Activity during classes, participation in discussions, scientific paper, presentation.

Literature
Obligatory:

1. K. K. Tung - *Topics in Mathematical Modeling*, Princeton University Press, 2007.
2. R. Penrose, *Droga do rzeczywistości - wyczerpujący przewodnik po prawach rządzących Wszechświatem*, Świat Nauki - Prószyński i S-ka, 2011.
3. E. Wigner, *The Unreasonable Effectiveness of Mathematics in the Natural Sciences*, Communications in Pure and Applied Mathematics, vol. 13, No. I (February 1960).
   Optional:
4. L. Kinsler, A. Frey, A. Coppens, J. Sanders, *Fundamentals of Acoustics*, J. Willey and Sons.
5. G.V. Coyne, M. Heller, *Pojmowalny Wszechświat*, Świat Nauki - Prószyński i S-ka, 2007.
6. *Springer Handbook of Acoustics*, Springer-Verlag New York, 2007.
7. R. Rienstra, A. Hirschberg, *An Introduction to Aeroacoustics*, Large-Eddy simulation for acoustics, Cambridge University Press, 2007.
8. F. Jacobsen, P.M. Juhl, *Fundamentals of General Linear Acoustics*, John Wiley and Sons, 2013.
9. A. Snakowska, *Badania teoretyczne i eksperymentalne falowodów cylindrycznych*, Postępy Akustyki 2017, OSA Piekary Śląskie 2017, pp. 83-109.
10. Heller, T. Pabjan, *Elementy filozofii przyrody*.
11. Relevant websites and scientific articles.

Wireless Technologies

Basic Information
• **Field of Study**: Acoustic Engineering
• **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
• **Study Level**: First-cycle (Engineer) Programme
• **Form of Study**: Full-time Studies
• **Profile**: General Academic
• **Didactic Cycle**: 2021/2022
• **Course Code**: RIAKS.Ii20K.02615.21
• **Lecture Languages**: Polish
• **Mandatoriness**: Elective
• **Block**: Core Modules
• **Course Related to Scientific Research**: Yes
• **Course Coordinator**: Janusz Młynarczyk
• **Lecturer**: Janusz Młynarczyk
• **Period**: Semester 6

Activities and Hours
• **Lectures**: 20 hours
• **Laboratory Classes**: 20 hours
• **Number of ECTS Credits**: 4

Course Goals
• C1: Introduce students to essential wireless transmission techniques used in modern wireless systems.

Learning Outcomes
Knowledge:
• W1: Understands fundamental modulation and coding techniques for wireless transmission, radio channel issues, and antenna systems.
• W2: Understands the operation of wireless systems used for acoustic signal transmission, especially radio broadcasting and mobile phone systems.
• W3: Understands wireless transmission methods in wireless computer networks.

Skills:
• U1: Can use software to analyze the performance of wireless systems, evaluate their capabilities, and select appropriate antennas for data transmission systems.

Student Workload
• **Lectures**: 20 hours
• **Laboratory Classes**: 20 hours
• **Preparation for Classes**: 10 hours
• **Independent Tasks**: 30 hours
• **Examination or Final Test**: 2 hours
• **Preparation of Reports**: 20 hours
• **Total Workload**: 102 hours
• **Teacher Workload**: 40 hours

Program Content

1. **Fundamentals of Wireless Systems**
   • Radio bands and their use, wireless system block diagrams, radio channel concept, wireless link budget, noise, interference, multipath, fading, radio wave propagation in urban environments, wireless system architectures, bidirectional and multiple access transmission methods.
2. **Wireless Local Area Networks (WLAN)**
   • Wireless transmission techniques in computer networks, spread spectrum, multi-carrier transmission, physical layer details of IEEE 802.11 standards (Wi-Fi).
3. **Radio Broadcasting Systems**
   • Analog and digital radio systems, Digital Radio Mondiale, Digital Audio Broadcasting, Digital Multimedia Broadcasting.
4. **Mobile Communication Systems**
   • Construction and operation of cellular systems, wireless transmission techniques in cellular systems.
5. **Antennas**
   • Basic antenna techniques and antenna construction.
6. **Modeling and Analysis of Wireless Systems**
   • Using software to analyze wireless transmission techniques to reinforce lecture content, modeling simple antenna structures, implementing simple wireless transmissions using software-defined radio devices.

Teaching Methods
• Lectures, Laboratory Work, Software Simulations

Literature
Obligatory:
• Lecture materials from the course "Wireless Techniques"

Optional:

1. K. Wesołowski, *Systemy radiokomunikacji ruchomej*, WKŁ, Warsaw, 2006
2. W. Hołubowicz, M. Szwabe, *Systemy radiowe z rozpraszaniem widma, CDMA: teoria, standardy, aplikacje*, Poznań, Motorola Polska, 1998
3. D.M. Pozar, *Microwave and RF Wireless Systems*, John Wiley & Sons, 2001

Analogue Peripheral Circuits in Digital Systems

Basic Information

- **Field of Study**: Acoustic Engineering
- **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
- **Study Level**: First-cycle (Engineer) Programme
- **Form of Study**: Full-time Studies
- **Profile**: General Academic
- **Didactic Cycle**: 2021/2022
- **Course Code**: RIAKS.Ii40K.02591.21
- **Lecture Languages**: Polish
- **Mandatoriness**: Elective
- **Block**: Core Modules
- **Course Related to Scientific Research**: No
- **Course Coordinator**: Przemysław Krehlik, Łukasz Śliwczyński
- **Lecturers**: Przemysław Krehlik, Łukasz Śliwczyński
- **Period**: Semester 7

Activities and Hours

- **Lectures**: 14 hours
- **Laboratory Classes**: 14 hours
- **Number of ECTS Credits**: 2

Course Goals

- **C1**: Introduce students to the design and simulation of analog and mixed-signal circuits for digital systems.
- **C2**: Develop practical skills in implementing low-noise, wideband signal conditioning and analog-to-digital/digital-to-analog conversion.

Learning Outcomes

Knowledge:

- **W1**: Understands the theoretical principles of analog-to-digital and digital-to-analog conversion systems.
- **W2**: Comprehends the methods for designing analog, digital, and mixed-signal electronic circuits; knows how to use computer tools for circuit and system design and simulation.

Skills:

- **U1**: Can gather and interpret information from literature, databases, and other sources to critically evaluate and draw conclusions.
- **U2**: Can plan the testing process for designed electronic circuits.

Social Competences:

- **K1**: Demonstrates creativity in problem-solving and design of electronic circuits.

Student Workload

- **Lectures**: 14 hours
- **Laboratory Classes**: 14 hours
- **Preparation for Classes**: 22 hours
- **Total Student Workload**: 50 hours
- **Workload Involving Teacher**: 28 hours

(*One hour means 45 minutes*)

Program Content

1. **Laboratory**
   Simulation, design, and measurement of low-noise modules for signal amplification and conditioning in acoustic signal conversion from analog to digital.
   Learning Outcomes: W2, U1, U2, K1
   Activity: Laboratory classes
2. **Low-Noise and Wideband Input Stages**
   Noise models of components and electronic circuits, noise analysis of operational amplifier circuits, amplifier selection, and design of input stages.
   Learning Outcomes: W2, U1
   Activity: Lectures
3. **Analog Signal Conditioning in A/D and D/A Conversion**
   Signal buffering in A/D conversion, output buffer matching, anti-aliasing filters,

reconstruction filters, oversampling, and differential signal processing.
Learning Outcomes: W2, U1
Activity: Lectures

4. **Differential and Current Signal Processing**
   Measurement of differential signals with large summation components, differential amplifiers, ground-loop current measurements, galvanic isolation issues, RF signal measurement, and logarithmic scale signal processing.
   Learning Outcomes: W2, U2
   Activity: Lectures

5. **Architectures of A/D and D/A Converters**
   Over-sampling converters, "pipeline" converters, parameters of converters (ENOB, SINAD, THD, THD+N), measurement methods, multi-channel data acquisition systems.
   Learning Outcomes: W1, W2, U1, U2
   Activity: Lectures

6. **Sigma-Delta Acoustic Converters**
   Study of sigma-delta converters used in acoustic signal processing.
   Learning Outcomes: W1, W2, U1, U2
   Activity: Lectures

Teaching Methods
Lectures, Group Work, Discussion, Laboratory Classes

Activities

- **Lectures**: Project
- **Laboratory Classes**: Execution of Laboratory Work, Project, Essay

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Literature

Obligatory:

1. Johnson H., Graham M. – *High-speed digital design: Prentice Hall, 1993*
2. Johnson H., Graham M. – *High-speed signal propagation: Prentice Hall, 2003*
3. Company literature: Analog Devices, Linear Technology, Maxim, Texas Instruments

Digital and Microprocessor Technology

Basic Information

- **Field of Study**: Acoustic Engineering
- **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
- **Study Level**: First-cycle (Engineer) Programme
- **Form of Study**: Full-time Studies
- **Profile**: General Academic
- **Didactic Cycle**: 2021/2022
- **Course Code**: RIAKS.Ii40K.02613.21
- **Lecture Languages**: Polish
- **Mandatoriness**: Obligatory
- **Block**: Core Modules
- **Course Related to Scientific Research**: Yes
- **Course Coordinator**: Paweł Pawlik
- **Lecturers**: Paweł Pawlik, Robert Barański, Tomasz Korbiel
- **Period**: Semester 7

Activities and Hours

- **Lectures**: 28 hours
- **Laboratory Classes**: 28 hours
- **Number of ECTS Credits**: 4

Course Goals

- **C1**: Provide knowledge on the construction and operation of digital electronic circuits, programmable circuits, microprocessors, microcontrollers, and microcomputers.
- **C2**: Introduce students to the AVR family programming environment.
- **C3**: Teach the implementation of vibration measurement devices and signal generators using microcontrollers.
- **C4**: Provide knowledge on FPGA systems, compilation, logical operations, and filtering.

- **C5**: Teach A/D converter handling techniques.
- **C6**: Instruct students on acoustic and vibroacoustic measurement systems using real-time operating systems.
- **C7**: Provide knowledge on the construction and programming of Raspberry Pi-based microcomputers.

Learning Outcomes

Knowledge:

- **W1**: Student has theoretical knowledge about the construction, operation, and parameters of digital electronic circuits.
- **W2**: Student understands the principles of programmable systems, microprocessors, and microcontrollers.

Skills:

- **U1**: Student can formulate specifications for simple digital circuits and verify them.
- **U2**: Student can design digital electronic circuits using appropriate methods, techniques, and tools.
- **U3**: Student can read and create graphical and textual technical documentation (drawings, diagrams, charts), and create documentation using computer-aided design tools.

Social Competences:

- **K1**: Student understands the importance of continuous learning and professional development.
- **K2**: Student is aware of the responsibility for their work and is willing to cooperate in a team environment.

Student Workload

- **Lectures**: 28 hours
- **Laboratory Classes**: 28 hours
- **Preparation for Classes**: 10 hours
- **Independent Tasks**: 22 hours
- **Examination or Final Test**: 2 hours
- **Preparation of Reports**: 30 hours
- **Total Student Workload**: 120 hours

- **Workload Involving Teacher**: 56 hours

Program Content

1. **Introduction to AVR Programming**
   Introduction to programming AVR microcontrollers, communication with a PC, implementation of digital I/O handling using shift registers, and interrupt handling.
   Learning Outcomes: W1, W2, U1, U2, K1, K2
   Activity: Laboratory classes
2. **Vibration Measurement Device**
   Design and implementation of a vibration measurement device based on acquired knowledge, using sensors such as MEMS and signal processing techniques.
   Learning Outcomes: W1, W2, U1, U2, K1, K2
   Activity: Laboratory classes
3. **Signal Generator Construction**
   Design and implementation of a signal generator using microcontrollers, exploring the impact of using interrupts on the system design.
   Learning Outcomes: W1, W2, U1, U2, K1, K2
   Activity: Laboratory classes
4. **FPGA Systems Programming**
   Introduction to FPGA system programming with LabVIEW, logical operation implementation, filtering, spectral analysis, and numerical integration in FPGA systems.
   Learning Outcomes: W1, W2, U1, U2, K1, K2
   Activity: Laboratory classes
5. **A/D Conversion in FPGA Systems**
   Practical training in handling A/D converters in FPGA systems with communication protocols.
   Learning Outcomes: W1, W2, U1, U2, K1, K2
   Activity: Laboratory classes
6. **Real-Time Acoustic and Vibroacoustic Measurements**
   Implementation of real-time acoustic and vibroacoustic measurement systems using FPGA and real-time operating systems.
   Learning Outcomes: W1, W2, U1, U2, K1, K2
   Activity: Laboratory classes
7. **Raspberry Pi Programming**
   Introduction to Raspberry Pi microcomputers, with an emphasis on digital I/O handling and the development of a vibroacoustic measurement system that communicates with a PC.
   Learning Outcomes: W1, W2, U1, U2, K1, K2
   Activity: Laboratory classes

Teaching Methods

Group Work, Discussion, Lectures, Case Study, Demonstration, Team-Based Learning

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Methods of Verification

- **Lectures**: Activity during classes, Test, Examination
- **Laboratory Classes**: Activity during classes, Test, Report, Involvement in Teamwork

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Literature

Obligatory:

1. Simon Monk – *Arduino dla początkujących: podstawy i szkice*, Helion 2014
2. Martin Evans, Joshua Noble, Jordan Hochenbaum – *Arduino w akcji: poznaj możliwości platformy Arduino!*, Helion 2014
3. Ed Doering – *NI myRIO Project Essentials Guide*, National Instruments 2016

Optional:

1. Dariusz Świsulski – *Przykłady cyfrowego przetwarzania w LabVIEW*, Politechnika Gdańska 2014

Dissertation Seminar in Sound in Media and Art

Basic Information
- **Field of Study**: Acoustic Engineering
- **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
- **Study Level**: First-cycle (Engineer) Programme
- **Form of Study**: Full-time Studies
- **Profile**: General Academic
- **Didactic Cycle**: 2021/2022
- **Course Code**: RIAKS.Ii40K.04944.21
- **Lecture Languages**: Polish
- **Mandatoriness**: Elective
- **Block**: Core Modules
- **Course Related to Scientific Research**: Yes
- **Course Coordinator**: Piotr Kleczkowski
- **Lecturer**: Piotr Kleczkowski
- **Period**: Semester 7

Activities and Hours
- **Seminars**: 14 hours
- **Number of ECTS Credits**: 1

Course Goals
- **C1**: Help students in planning, executing, writing, editing, and presenting their dissertations during defense.
- **C2**: Introduce students to basic principles of interpersonal communication and assist in developing their own communication style.

Learning Outcomes
Skills:
- **U1**: Can apply knowledge and skills acquired during the studies to perform an independent, complex engineering task.
- **U2**: Can gather theoretical knowledge and technical solutions beyond the scope of their studies, required for dissertation completion.
- **U3**: Can properly document and present experimental and project results.

Social Competences:
- **K1**: Ready to collaborate with partners necessary for executing complex engineering tasks from different backgrounds, from fellow students to representatives of the industry and public sectors.

• **K2**: Able to effectively communicate results of their work to recipients from various economic and public sector domains.

Student Workload
• **Seminars**: 14 hours
• **Preparation for Classes**: 2 hours
• **Preparation of Project, Presentation, Essay, Report**: 12 hours
• **Total Workload**: 28 hours
• **Teacher Workload**: 14 hours

Program Content

1. **Fundamentals of Planning Experimental and Design Work**
   • Learning Outcomes: U1, U2
   • Activity: Seminars
2. **Basic Principles of Documenting Results and Writing a Dissertation**
   • Learning Outcomes: U1, U2, U3
   • Activity: Seminars
3. **Basic Principles of Interpersonal Communication**
   • Learning Outcomes: U3, K1, K2
   • Activity: Seminars
4. **Basic Principles of Preparing Audiovisual Presentations**
   • Learning Outcomes: U1, U3, K1, K2
   • Activity: Seminars

Teaching Methods
• Lectures, Discussion, Peer Assessment

Literature
Obligatory:

1. Wasylczyk P., *Prezentacje naukowe - praktyczny poradnik dla studentów, doktorantów i nie tylko*, Wydawnictwo Naukowe PWN SA, Warszawa 2017.

Diploma Project

Basic Information
- **Field of Study**: Acoustic Engineering
- **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
- **Study Level**: First-cycle (Engineer) Programme
- **Form of Study**: Full-time Studies
- **Profile**: General Academic
- **Didactic Cycle**: 2021/2022
- **Course Code**: RIAKS.Ii40K.00034.21
- **Lecture Languages**: Polish
- **Mandatoriness**: Elective
- **Block**: Core Modules
- **Course Related to Scientific Research**: No
- **Course Coordinator**: Leszek Majkut
- **Lecturer**: Leszek Majkut
- **Period**: Semester 7

Activities and Hours
- **Diploma Thesis**: 0 hours
- **Number of ECTS Credits**: 15

Course Goals
- C1: Assist students in properly planning, executing, writing, editing, and presenting their diploma thesis.
- C2: Familiarize students with fundamental principles of interpersonal communication and help them develop their own communication style.

Learning Outcomes

Knowledge:
- W1: Possesses in-depth knowledge related to the topic of the diploma thesis.

Skills:
- U1: Can independently search for sources of information and solve complex research and technical problems encountered during the project.
- U2: Can plan and execute all tasks related to the project and document them appropriately.

Social Competences:
- K1: Develops the ability to collaborate with the advisor (supervisor) and other individuals or institutions necessary to complete the diploma thesis.

Student Workload
• **Realization of Independently Performed Tasks**: 150 hours
• **Contact Hours**: 5 hours
• **Preparation of Project, Presentation, Essay, Report**: 250 hours

Total Workload: 405 hours
(*hour means 45 minutes*)

Program Content

1. **Consultations with the Thesis Supervisor**
   • Discussing the concept and scope of the thesis, building computational and laboratory models, measurements, and calculations.
   • Detailed consultations during the execution of laboratory experiments and analytical/numerical calculations.
   • Consultations regarding the structure and development of the thesis.
   • Independent work of the student, including research, calculations, and final thesis preparation.

Learning Outcomes: W1, U1, U2, K1
Activities: Thesis work and consultations

2. **Thesis Preparation and Execution**
   • The thesis should be a creative study of the chosen topic based on literature and the student's own research.
   • Students must demonstrate proficiency in creating computational models, building laboratory setups, and designing control systems for complex mechanical systems.
   • Analytical and numerical calculations must be performed.
   • The final thesis should not exceed 100 pages and must clearly define the goal, approach, and conclusions.
   • A list of referenced literature should be included, formatted according to university guidelines.
   • The thesis should be submitted electronically and in hard copy.

Learning Outcomes: W1, U1, U2, K1
Activities: Thesis preparation

Teaching Methods and Techniques
• Discussion, Individual Consultations

Activities and Methods of Verification
• **Thesis**: Thesis preparation
• **Credit Conditions**: Successful completion of the diploma thesis

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Literature
Obligatory:
• Literature is selected during consultations with the thesis supervisor.

Image Processing

Basic Information
- **Field of Study:** Acoustic Engineering
- **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
- **Study Level:** First-cycle (Engineer) Programme
- **Form of Study:** Full-time Studies
- **Profile:** General Academic
- **Didactic Cycle:** 2021/2022
- **Course Code:** RIAKS.Ii40K.02556.21
- **Lecture Languages:** Polish
- **Mandatoriness:** Elective
- **Block:** Core Modules
- **Course Related to Scientific Research:** Yes
- **Course Coordinator:** Przemysław Korohoda
- **Lecturers:** Przemysław Korohoda
- **Period:** Semester 7

Method of Verification of the Learning Outcomes
- Completing the classes

Activities and Hours
- **Lectures:** 18 hours
- **Laboratory Classes:** 18 hours
- **Number of ECTS Credits:** 2

Course Goals
- **C1:** Introduce students to fundamental concepts, models, and algorithms in image processing.
- **C2:** Explain the process of image processing from acquisition or generation to saving or transmission in file format.
- **C3:** Clarify similarities and differences between acoustic signal processing and image processing.

Learning Outcomes
Knowledge:
- **W1:** Understands basic models and techniques of image and video sequence processing, interdependencies, and the relationship between theoretical descriptions and practical effects of selected algorithms.

• **W2:** Understands similarities and differences between acoustic signal processing and image processing techniques.

Skills:
• **U1:** Can select appropriate computational methods for a task, predict time and sequence of steps, and perform engineering tasks within the constraints of laboratory sessions, using computer assistance.

Social Competences:
• **K1:** Can organize and complete tasks within a small team, effectively utilizing its members' strengths, while maintaining mutual respect.

Student Workload
• **Lectures:** 18 hours
• **Laboratory Classes:** 18 hours
• **Preparation for Classes:** 7 hours
• **Independent Tasks:** 7 hours
• **Total Workload:** 50 hours
• **Teacher Workload:** 36 hours

Program Content

1. **Introduction to Image Processing**
   • Overview, digital image models, interdependencies, visualization and representation methods for digital images.
   • Histogram and its applications in image processing. Context-free operators (pixel-based).
   • Convolution and correlation operators (linear) – examples of filters and intuitive interpretation.
   • Discrete Fourier Transform applied to images, convolution filtering interpretation.

2. **Advanced Image Processing Methods**
   • Linear and nonlinear methods for edge detection and enhancement.
   • Noise models in digital images, noise reduction techniques.
   • Fundamentals and methods of image segmentation.
   • Radon and Hough transforms and other specific methods for alternative image representation.
   • Geometric transformations (deformations) of digital images.
   • Morphological methods and logical filtering.

3. **Compression Topics**
   • Introduction and algorithms for digital image compression, JPEG and JPEG2000 standards.
   • Introduction and algorithms for video sequence compression, MPEG standard elements.

4. **AI Topics in Image Processing**
   • Selected techniques in deep learning, such as Convolutional Neural Networks and neural network training methods.

5. **Summary and Review**
   • Review of presented material with additional comments and clarifications.

Laboratory Classes

1. **Introduction and Basic Methods**
   • Introduction, course rules, review of selected Matlab techniques.
   • Color models for digital images, representation and examination of digital image content – examples and self-experiments.
   • Examples and experiments with pixel-based operators.
   • Examples of convolution operators and self-project during classes.
   • Applications and interpretation of results for 2D Fourier Transform, connection with convolution filtering, examples and self-projects during classes.

2. **Advanced Image Processing Techniques**
   • Edge detection and noise reduction methods, examples, and mini-project during class.
   • Segmentation methods and Hough transform, examples, and mini-project during class.
   • Geometric transformations, logical operators, and morphological methods, examples, and mini-project during class.

3. **Compression Topics**
   • Components of image compression methods, examples, and mini-project during class.
   • Utilization of object motion in video sequence compression, examples, and mini-project during class.

4. **AI Topics**
   • Selected calculations used in deep learning algorithms.

5. **Final Test**

Extended Information / Additional Elements

Teaching Methods and Techniques:
• Lectures, Discussion, Flipped Classroom, Peer Assessment

Activities and Methods of Verification:
• **Lectures:** Activity during classes, participation in discussion, execution of laboratory tasks, test results.
• **Laboratory Classes:** Activity during classes, participation in discussion, execution of laboratory tasks, teamwork involvement, test results.

Credit Conditions:
• Obtain credit for laboratory work.
• Pass all laboratory sections according to established guidelines and final test.

Literature
Obligatory:

1. Z. Wróbel, R. Koprowski – *Praktyka przetwarzania obrazów w programie Matlab*, Exit, Warszawa, 2004.
2. L. Wojnar, K.J. Kurzydłowski, J. Szala – *Praktyka analizy obrazu*, Polskie Wydawnictwo Stereologiczne, Kraków, 2002.
3. M. Domański – *Obraz cyfrowy*, WKŁ, Warszawa, 2010.

Optional:

1. S.G. Hoggar – *Mathematics of Digital Images: Creation, Compression, Restoration, Recognition*, Cambridge Univ. Press, Cambridge, 2006.

Object-Oriented Methods of System Design

Basic Information
- **Field of Study:** Acoustic Engineering
- **Organizational Unit:** Faculty of Mechanical Engineering and Robotics
- **Study Level:** First-cycle (Engineer) Programme
- **Form of Study:** Full-time Studies
- **Profile:** General Academic
- **Didactic Cycle:** 2021/2022
- **Course Code:** RIAKS.Ii40K.02610.21
- **Lecture Languages:** Polish
- **Mandatoriness:** Elective
- **Block:** Core Modules
- **Course Related to Scientific Research:** No
- **Course Coordinator:** Roman Trojanowski
- **Lecturer:** Roman Trojanowski
- **Period:** Semester 7

Activities and Hours
- **Lectures:** 14 hours
- **Project Classes:** 10 hours
- **Number of ECTS Credits:** 2

Course Goals
- C1: Introduce students to object-oriented analysis and design methods using UML and Java.
- C2: Equip students with practical skills in object-oriented programming, design patterns, and component-based development.

Learning Outcomes
Knowledge:
- W1: Understands object-oriented analysis and design methods, including the use of UML.
- W2: Has basic knowledge of Java programming.

Skills:
- U1: Can create software using Java and apply design patterns and component-based techniques.
- U2: Can apply software engineering principles, code testing, refactoring, and use tools for team collaboration.

Social Competences:
- K1: Communicates knowledge effectively, including in collaborative and professional settings.

Student Workload
• **Lectures:** 14 hours
• **Project Classes:** 10 hours
• **Contact Hours:** 5 hours
• **Preparation for Project:** 30 hours
• **Total Workload:** 59 hours
• **Teacher Workload:** 24 hours

Program Content

1. **Introduction to Object-Oriented Analysis and Design**
   • Object-oriented modeling using classes, objects, and relationships.
   • Introduction to UML: static and dynamic dependency modeling, use case diagrams, class diagrams, sequence diagrams, state diagrams, collaboration diagrams, activity diagrams, component diagrams.
   • Generics programming using Java Collections Framework.
   • Design Patterns: Singleton, Factory, Adapter, Facade, Composite, Proxy, Observer, Visitor, and Strategy.
   • MVC (Model-View-Controller) pattern.
   • Component-based programming: composition principles, object dependencies, lightweight containers (inversion of control).
   • Software testing with JUnit, code refactoring principles.
   • Team collaboration tools: Version control systems (SVN).
   Activities: Project Classes

2. **Advanced Object-Oriented Programming and Parallel System Design**
   • Object-oriented modeling in parallel and distributed systems using Java RMI and concurrent collections.
   • Differences between Java and C++.
   • Advanced UML modeling techniques: class diagrams, sequence diagrams, component diagrams.
   • Software testing with JUnit, code refactoring principles.
   • Team collaboration tools: Version control systems (Git).
   • Mobile application programming in Java (Introduction to Android platform).
   Activities: Lectures

Teaching Methods
• Lectures, Project Classes, Group Discussions

Literature
Obligatory:

1. Bruce Eckel – *Thinking in Java*
2. Sun Microsystems – *Java Tutorial*
3. Bruce E. Wampler – *The Essence of Object-Oriented Programming with Java(TM) and UML*
4. Erich Gamma, Richard Helm, Ralph Johnson, John Vissides – *Design Patterns*
5. Bruce Eckel – *Thinking in Patterns with Java*
6. Kent Beck, Martin Fowler, William Opdyke, Don Roberts – *Refactoring: Improving the Design of Existing Code*
7. Martin Fowler – *UML Distilled* (Version 2.0)

Practical Audio Production

Basic Information
• **Field of Study**: Acoustic Engineering
• **Organizational Unit**: Faculty of Mechanical Engineering and Robotics
• **Study Level**: First-cycle (Engineer) Programme
• **Form of Study**: Full-time Studies
• **Profile**: General Academic
• **Didactic Cycle**: 2021/2022
• **Course Code**: RIAKS.Ii40K.08815.21
• **Lecture Languages**: Polish
• **Mandatoriness**: Elective
• **Block**: Core Modules
• **Course Related to Scientific Research**: Yes
• **Course Coordinator**: Paweł Małecki
• **Lecturer**: Paweł Małecki
• **Period**: Semester 7

Activities and Hours
• **Laboratory Classes**: 56 hours
• **Number of ECTS Credits**: 4

Course Goals
• C1: Develop practical skills in operating both analog and digital audio mixing consoles.
• C2: Introduce students to audio effects like equalization, compression, and reverb for sound manipulation.
• C3: Teach students how to create a desired sound space in a recording and produce a final stereo mix.

Learning Outcomes

Skills – Student can:
• **U1**: Operate both analog and digital mixing consoles.
• **U2**: Apply audio effects such as EQ and compression to achieve a desired sound.
• **U3**: Create spatial effects using reverb processors.
• **U4**: Produce a final stereo mix to a file.

Student Workload
• **Laboratory Classes**: 56 hours
• **Preparation for Classes**: 30 hours

- **Preparation of Project/Presentation**: 15 hours
- **Total Workload**: 101 hours
- **Workload Involving Teacher**: 56 hours

Program Content

1. **Introduction to Sound Systems**
   - Familiarization with near-field, mid-field, and far-field listening systems.
   - **Learning Outcomes**: U1, U2, U3, U4
   - **Activities**: Laboratory classes

2. **Digital Console Operation (Yamaha DM2000)**
   - Operating a digital mixing console, learning its functionalities.
   - **Learning Outcomes**: U1, U2, U3, U4
   - **Activities**: Laboratory classes

3. **Recording Sound Effects**
   - Techniques for capturing various sound effects for production.
   - **Learning Outcomes**: U1, U2, U3, U4
   - **Activities**: Laboratory classes

4. **Creating a Sound Drama**
   - Producing a sound drama incorporating various audio elements.
   - **Learning Outcomes**: U1, U2, U3, U4
   - **Activities**: Laboratory classes

5. **Mixing Classical Music**
   - Techniques for mixing classical music tracks.
   - **Learning Outcomes**: U1, U2, U3, U4
   - **Activities**: Laboratory classes

6. **Mixing Jazz/Folk Music**
   - Approaches to mixing jazz and folk music tracks.
   - **Learning Outcomes**: U1, U2, U3, U4
   - **Activities**: Laboratory classes

7. **Mixing Pop/Entertainment Music**
   - Techniques for mixing popular and entertainment music tracks.
   - **Learning Outcomes**: U1, U2, U3, U4
   - **Activities**: Laboratory classes

Teaching Methods

- Project-based learning
- Hands-on practice with industry-standard equipment
- Active participation in class activities

Activities & Methods of Verification
• **Laboratory Classes**: Activity during classes, project-based assignments
• **Credit Conditions**: Completion of all laboratory classes with satisfactory project results

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Literature
Obligatory

1. Roey Izhaki – *Mixing Audio: Concepts, Practices and Tools*, Focal Press, 2011
2. Alex Case – *Mix Smart: Pro Audio Tips For Your Multitrack Mix*, Focal Press, 2011
3. Bobby Owsinski – *The Mixing Engineer's Handbook*, Course Technology, 2014
4. Bob Katz – *Mastering Audio: The Art and the Science*, Focal Press, 2007