

## **Рабочая программа дисциплины**

**1. Название дисциплины:** Introduction to Acoustics.

**2. Лектор (Lecturer).**

**2.1.** Doctor of Physical and Mathematical Sciences, Professor Alexander Ivanovich Korobov, Department of Acoustics, aikor42@mail.ru, tel. (495) 939-18-21.

**3. Аннотация дисциплины (Annotation).**

The course provides basic information on acoustics. The data on the sound field and its characterizing values are given. The problems of reflection and refraction of waves at the plane interface and an acoustic waveguide, the problems of geometrical acoustics and acoustics of the moving medium, the problems of the radiation, scattering and absorption of sound are reviewed. Basic information on acoustics in solids, nonlinear acoustics, physiological acoustics and electroacoustics are presented.

**4. Цели освоения дисциплины.**

The purpose of discipline is to learn the basic techniques and problem solving approaches for the propagation of sound in air, water and solids.

**5. Задачи дисциплины.**

Tasks of the course are

(1) an introduction to the basic concepts of acoustics in air, water and solids, physiological acoustics, and

(2) solving of simple problems of acoustics: the reflection and refraction of waves at the plane interface, the waveguide propagation of sound, problems of geometrical acoustics, acoustics of moving media, problems of radiation, scattering and absorption of sound.

**6. Компетенции.**

**6.1. Компетенции, необходимые для освоения дисциплины.**

ПК-1, ПК-6

**6.2. Компетенции, формируемые в результате освоения дисциплины.**

ПК-3, ПК-4

**7. Требования к результатам освоения содержания дисциплины**

As a result of learning the discipline, the student must:

- To know the basic techniques and approaches for solving problems of sound propagation in air, water and solids;
- To be able to solve simple problems of reflection and refraction at a plane interface between two media, the waveguide propagation of sound, geometrical acoustics, acoustics of moving media, radiation, scattering and absorption of sound.

## 8. Содержание и структура дисциплины.

Вид работы	Семестр			Всего
	5			
<b>Общая трудоёмкость, акад. часов</b>	72			72
<b>Аудиторная работа:</b>				
Лекции (lections), акад. часов	36			36
Семинары, акад. часов				
Лабораторные работы, акад. часов				
<b>Самостоятельная работа, акад. часов</b>	36			36
<b>Вид итогового контроля (зачёт, зачёт с оценкой, эк-замен)</b>	зач.			

N раз- дела	Наименование раздела	Трудоёмкость (академических часов) и содержание занятий		Форма текущего контроля
		Аудиторная работа	Самостоятельная работа	
		Лекции (36 academical hours)	(36 academical hours)	
1.	Hydrodynamic equations	<i>Lecture №1 (2 hours)</i> The acoustic field. Fundamental quantities characterizing it. The wave equation. Plane, spherical and cylindrical waves. The energy and momentum of the sound field. The flow of energy.	<i>3 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	<i>Home work (HW), Control work (CW)</i>
		<i>Lecture №2 (2 hours)</i> The equations of hydrodynamics. Ideal and viscous fluids.	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	
		<i>Lecture №3 (2 hours)</i> The wave equation. Plane, spherical and cylindrical waves. The energy and momentum of the sound field. The flow of energy.	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	
2.	Reflection and refraction of acoustic waves	<i>Lecture №4 (2 hours)</i> Reflection and refraction of plane waves at plane interfaces. Normal impedance of a boundary.	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	<i>HW, CW</i>
		<i>Lecture №5 (2 hours)</i> Acoustic waves in waveguides. Normal waves	<i>3 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	
		<i>Lecture №6 (2 hours)</i> Geometrical acoustics. Acoustic beams.	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	
3.	Radiation of sound	<i>Lecture №7 (2 hours)</i> The concept of the acoustics of moving media. Some details of the atmospheric acoustics and hydroacoustics	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	<i>HW, CW</i>
		<i>Lecture №8 (2 hours)</i> The emission of sound. The simple sound transmitters: monopole. Dipole. Added mass.	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	
		<i>Lecture №9 (2 hours)</i> Piston transmitter. The effectiveness of radiation and radiation impedance (active and reactive). Near and far field.	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	

4.	Acoustic Waves in Solids	<i>Lecton №10 (2 hours)</i> Scattering and absorption of sound.	<i>3 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	<i>HW, CW</i>
		<i>Lecton №11 (2 hours)</i> Acoustic waves in solids. Elements of the theory of elasticity. Longitudinal and transverse waves.	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	
		<i>Lecton №12 (2 hours)</i> Reflection and refraction of acoustic plane waves at a plane boundary between isotropic solids.	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	
		<i>Lecton №13 (2 hours)</i> The cut-off waves. Rayleigh surface wave. Lamb waves. Wedge wave.	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	
		<i>Lecton №14 (2 hours)</i> A summary of the electroacoustic. Electromechanical and piezoelectric transducers.	<i>3 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	
5.	Nonlinear Acoustics	<i>Lecton №15 (2 hours)</i> Nonlinear acoustics of liquids and gases. The theory of the Riemann. The effect of viscosity. The weak periodic shock wave	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	<i>HW, CW</i>
		<i>Lecton №16 (2 hours)</i> Nonlinear acoustics of solids. Nonlinear parameter. Conditions of synchronism in the three-phonon interactions. The physical mechanism of sound absorption due to the interaction of sound with thermal phonons.	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	
6.	Physiological acoustics	<i>Lecton №17 (2 hours)</i> Physiological Acoustics. The human ear. The sensitivity of the ear. The hearing threshold.	<i>2 hours</i> Working with the lecture material and reading the recommended literature. Solving three tasks on the lecture.	<i>HW, CW</i>
		<i>Lecton №18 (2 hours)</i> The Weber-Fechner law. Level of the sound. The binaural effect		

**Предусмотрены следующие формы текущего контроля успеваемости.**

1. Home work (HW),
2. Control work (CW)

## 9. Место дисциплины в структуре ООП ВПО

1. Дисциплина является обязательной.
2. Вариативная часть, профессиональный блок, дисциплина профиля.
3. Изложение опирается на знания, полученные студентами ранее в дисциплинах по математике и общей физике.
  - 3.1. Перечислить дисциплины и практики, которые должны быть освоены для начала освоения данной дисциплины.

Mathematical analysis, General Physics

- 3.2. Курс является вводным базисом к дисциплинам:

«Physical acoustics», «The theory of Acoustics», «Wave theory», scientific and research practice, following tasks of special laboratory course of Acoustic Department: «Speed-of-sound measurement in liquid», «Ultrasound in solids».

## 10. Образовательные технологии

The course is available online for a presentation. The lectures are given using the latest multimedia features and projection equipment. Teaching is in the form of original courses using the programs, developed on the basis of the results of scientific research schools of Moscow State University. Discussions, round tables, workshops of experts and specialists are held.

## 11. Оценочные средства для текущего контроля успеваемости и промежуточной аттестации

The **interim certification** is carried out at the week 8 in the form of the Control work with grades. A criterion for assessment is the knowledge level of a passed part of the course.

The **current certification** is carried out weekly. Criteria for assessment are attendance, student activity on lectures.

### Examples of tasks for homework and control works.

1. Calculate amplitudes of particle velocity and displacement in plane acoustical wave in air with the frequency of 1 kHz, where amplitude of sound pressure is  $2 \cdot 10^{-5}$  Pa.
2. Express particle velocity and sound pressure of plane acoustic wave in potential.
3. Find an «acoustical Ohm's law» for plane acoustical wave in gas.
4. Calculate near field of a piston transmitter with a radius equal to 10 wave lengths.
5. Find the coefficient of reflection of the plane longitudinal acoustic wave from the boundary between two gases: oxygen and nitrogen.
6. Calculate the critical angle for total reflection from the air -water interface.
7. Draw a vector diagram for the reflection and transmission of longitudinal wave at a plane boundary between two solids with different longitudinal and shear velocity.
8. Calculate the Young's modulus and Poisson's ratio for the isotropic aluminum whose specific gravity is equal to  $2700 \text{ kg/m}^3$ , the velocity of longitudinal waves is 6400 m/s, the velocity of shear waves is 3130 m/s.
9. Calculate the Lamé parameters in the isotropic iron with specific gravity of  $7900 \text{ kg/m}^3$ , longitudinal wave velocity is 5930 m/s, shear wave velocity is 3130 m/s.
10. Calculate the velocity of longitudinal and shear waves in titanium with specific gravity of  $4500 \text{ kg/m}^3$ , Young's modulus  $E = 110 \text{ GPa}$ . Shear coefficient  $G = 41,5 \text{ GPa}$ .

### Questions to examination

1. Fundamental quantities characterizing acoustical field.
2. The wave equation. Plane, spherical and cylindrical waves.
3. The equations of hydrodynamics. Ideal and viscous fluids.
4. The energy and momentum of the sound field. The flow of energy.

5. Reflection and refraction of plane waves at plane interfaces. Normal impedance of a boundary.
6. Acoustic waves in waveguides. Normal waves
7. Geometrical acoustics. Acoustic beams. The concept of the acoustics of moving media.
8. The emission of sound. The simple sound transmitters: monopole. Dipole. Added mass.
9. Piston transmitter. The effectiveness of radiation and radiation impedance (active and reactive). Near and far field.
10. Scattering and absorption of sound.
11. Acoustic waves in solids. Elements of the theory of elasticity. Longitudinal and transverse waves.
12. Reflection and refraction of acoustic plane waves at a plane boundary between isotropic solids.
13. The cut-off waves. Rayleigh surface wave. Lamb waves. Wedge wave..
14. Nonlinear acoustics of liquids and gases. The theory of the Riemann. Nonlinear acoustics of solids.
15. Nonlinear parameter. Conditions of synchronism in the three-phonon interactions. The physical mechanism of sound absorption due to the interaction of sound with thermal phonons.
16. Physiological Acoustics. The human ear. The sensitivity of the ear. The hearing threshold. The Weber-Fechner law. The binaural effect

## **12. Учебно-методическое обеспечение дисциплины**

### **General**

1. Krasil'nikov V.A. Introduction to Acoustics. - M.: MSU, 1992. (in Russian)
2. Acoustics in tasks (edited by S.N. Gurbatov and O.V. Rudenko).-M. Nauka, 1996. (in Russian)

### **Additional**

1. Rzhavkin S.N. Course of lectures on sound theory. - M.: MSU, 1960. (in Russian)
2. Shutilov V.A. Fundamentals of ultrasound physics. - L.: LSU, 1982. (in Russian)

### **Periodicals:**

1. Akusticheskij Zhurnal. MAIK. Nauka
2. Fizika.

### **Web site:**

[www.ioffe.ru](http://www.ioffe.ru)  
[www.akzh.ru](http://www.akzh.ru)

## **13. Материально-техническое обеспечение**

In accordance with the requirements of p. 5.3 of the MSU educational standard on the direction "Physics".

Lecture-room No 3-65.