TOMSK POLYTECHNIC UNIVERSITY | ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Министерство науки и высшего образования Российской Федерации
федеральное государственное автономное
образовательное учреждение высшего образования
«Национальный исследовательский Томский политехнический университет» (ТПУ)

School: School of Nuclear Science & Engineering
Field of training (specialty): 14.04.02 «Nuclear physics and technology»
Division: Division for Nuclear-fuel cycle

MASTER'S GRADUATION THESIS

Topic of research work
Development of a digital ascultometer for the diagnosis of heart murmurs

UDC 615.47:616-07:616.12-009.3

Student

Group	**Full name**	**Signature**	**Date**
0AM8M	Abdir Kulaikhan Shahatovna		

Scientific supervisor

Position	**Full name**	**Academic degree, academic rank**	**Signature**	**Date**
Associate Professor	Aleynik A.N	Ph.D		

Adviser

Position	**Full name**	**Academic degree, academic rank**	**Signature**	**Date**
Medical physicist Cancer Research Institute of Tomsk NRMC RAS	Turgunova N.D.			

ADVISERS:

Section "Financial Management, Resource Efficiency and Resource Saving"

Position	**Full name**	**Academic degree, academic rank**	**Signature**	**Date**
Associate Professor	Menshikova E.V.	Ph.D		

Section "Social Responsibility"

Position	**Full name**	**Academic degree, academic rank**	**Signature**	**Date**
Associate Professor	Verigin D.A.	Ph.D		

ADMITTED TO DEFENSE:

Director of programme	**Full name**	**Academic degree, academic rank**	**Signature**	**Date**
Nuclear medicine	Cherepennikov Yu. M.	Ph.D.		

Tomsk – 2020

Expected learning outcomes

Learning outcome (LO)code	Learning outcome (a graduate should be ready)	Requirements of the FSES HE, criteria and / or interested parties
Professional competencies		
LO1	To apply deep mathematical, scientific, socio-economic and professional knowledge for conducting theoretical and experimental research in the field of the use of nuclear science and technology.	FSES HE Requirements (BPC-1,2, PC-3, UC-1,3), Criterion 5 RAEE (p 1.1) requirements of the Ministry of Health and Social Development of the Russian Federation under the unified skills guide for positions of managers, specialists and non-manual workers for the position of “medical physicist”
LO2	To demonstrate ability to define, formulate, and solve interdisciplinary engineering tasks in the nuclear field using professional knowledge and modern research methods.	FSES HE Requirements (PC-9,10,13,14,15, BPC-1,3), Criterion 5 RAEE (p 1.2) requirements of the Ministry of Health and Social Development of the Russian Federation under the unified skills guide for positions of managers, specialists and non-manual workers for the position of “medical physicist”
LO3	To plan and conduct analytical, simulation and experimental studies in complex and uncertain conditions using modern technologies, and to evaluate critically research results.	FSES HE Requirements (PC-1,13,22, UC-2, BPC-1), Criterion 5 RAEE (p 1.3) requirements of the Ministry of Health and Social Development of the Russian Federation under the unified skills guide for positions of managers, specialists and non-manual workers for the position of “medical physicist”
LO4	To use basic and special approaches, skills and methods for identification, analysis, and solution of technical problems in the field of nuclear science and technology.	FSES HE Requirements (PC-2,4,6,8, UC-2, BPC-1), Criterion 5 RAEE (p 1.4) requirements of the Ministry of Health and Social Development of the Russian Federation under the unified skills guide for positions of managers, specialists and non-manual workers for the position of “medical physicist”
LO5	To operate modern physical equipment and instruments, to master technological processes in the course of preparation for the production of new materials, instruments, installations, and systems.	FSES HE Requirements (PC-5,7,11,12, UC-2, BPC-1), Criterion 5 RAEE (p 1.4) requirements of the Ministry of Health and Social Development of the Russian Federation under the unified skills guide for positions of managers, specialists and non-manual workers for the position of “medical physicist”
LO6	To demonstrate ability to develop multioption schemes for achieving production goals with the effective use of available technical means and resources.	FSES HE Requirements (PC-16-21,23), Criterion 5 RAEE (p 1.5) requirements of the Ministry of Health and Social Development of the Russian Federation under the unified skills guide for positions of managers, specialists and non-manual workers for

		the position of “medical physicist”
Cultural competencies		
LO7	To demonstrate ability to use a creative approach to develop new ideas and methods for designing nuclear facilities, as well as to modernize and improve the applied technologies of nuclear production.	FSES HE Requirements (BPC-1,3, UC-3), Criterion 5 RAEE (p 2.4,2.5)
Basic professional competencies		
LO8	To demonstrate skills of independent learning and readiness for continuous self-development within the whole period of professional activity.	FSES HE Requirements (UC-3, PC-1, BPC-1), Criterion 5 RAEE (p 2.6) requirements of the Ministry of Health and Social Development of the Russian Federation under the unified skills guide for positions of managers, specialists and non-manual workers for the position of “medical physicist”
LO9	To use a foreign language at a level that enables a graduate to function successfully in the international environment, to develop documentation, and to introduce the results of their professional activity.	FSES HE Requirements (PC-11,16,17, BPC-3), Criterion 5 RAEE (p 2.2) requirements of the Ministry of Health and Social Development of the Russian Federation under the unified skills guide for positions of managers, specialists and non-manual workers for the position of “medical physicist”
LO10	To demonstrate independent thinking, to function efficiently in command-oriented tasks and to have a high level of productivity in the professional (sectoral), ethical and social environments, to lead professional teams, to set tasks, to assign responsibilities and bear liability for the results of work.	FSES HE Requirements (PC-18,23, UC-2), Criterion 5 RAEE (p 1.6,2.3) requirements of the Ministry of Health and Social Development of the Russian Federation under the unified skills guide for positions of managers, specialists and non-manual workers for the position of “medical physicist”

TOMSK POLYTECHNIC UNIVERSITY — ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Министерство науки и высшего образования Российской Федерации
федеральное государственное автономное
образовательное учреждение высшего образования
«Национальный исследовательский Томский политехнический университет» (ТПУ)

School: School of Nuclear Science & Engineering
Field of training (specialty): 14.04.02 «Nuclear Physics and Technology»
Division: Division for Nuclear-fuel cycle

APPROVED BY:
Director of the programme
________ _______ Cherepennikov Yu.M.
(Signature) (Date) (Full name)

ASSIGNMENT
for the Graduation Thesis completion

In the form:

Master's thesis

For a student:

Group	**Full name**
0AM8M	Abdir Kulaikhan Shahatovna

Topic of research work:

Development of a digital ascultometer for the diagnosis of heart murmurs	
Approved by the order of the Director of School of Nuclear Science & Engineering (date, number):	

Deadline for completion of Master's Graduation Thesis:	

TERMS OF REFERENCE:

Initial data for research work: *(the name of the object of research or design; performance or load; mode of operation (continuous, periodic, cyclic, etc.); type of raw material or material of the product; requirements for the product, product or process; special requirements to the features of the operation of the object or product in terms of operational safety, environmental impact, energy costs; economic analysis, etc.)*	To create the layout of digital auscultate for diagnostic heart and lungs murmurs; study characteristics of the device.

List of the issues to be investigated, designed and developed *(analytical review of literary sources with the purpose to study global scientific and technological achievements in the target field, formulation of the research purpose, design, construction, determination of the procedure for research, design, and construction, discussion of the research work results, formulation of additional sections to be developed; conclusions).*	1. Review the literature on the research topic; 2. The development of laboratory layout digital auscultate; 3. A study of the technical characteristics of the constituent parts of digital auscultometer; 4. Conducting research on the diagnosis of heart and lung noise using the developed digital auscultometer; 5. Analysis of the results obtained and summing up. 6. Social responsibility; 7. Financial management, resource efficiency and resource conservation.
List of graphic material *(with an exact indication of mandatory drawings)*	

Advisors to the sections of the Master's Graduation Thesis
(with indication of sections)

Section	Advisor
Financial Management, Resource Efficiency and Resource Saving	Menshikova Ekaterina Valentinovna
Social Responsibility	Verigin Dan Alexandrovich

Date of issuance of the assignment for Master's Graduation Thesis completion according to the schedule	

Assignment issued by a scientific supervisor / advisor:

Position	Full name	Academic degree, academic ststus	Signature	Date
Associate professor	Aleynik A.N	Ph.D		
Medical physicist Cancer Research Institute of Tomsk NRMC RAS	Turgunova N.D.			

Assignment accepted for execution by a student:

Group	Full name	Signature	Date
0AM8M	Abdir Kulaikhan Shahatovna		

TOMSK POLYTECHNIC UNIVERSITY — ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Министерство науки и высшего образования Российской Федерации
федеральное государственное автономное
образовательное учреждение высшего образования
«Национальный исследовательский Томский политехнический университет» (ТПУ)

School: School of Nuclear Science & Engineering
Field of training (specialty): 14.04.02 «Nuclear Physics and Technology»
Division: Division for Nuclear-fuel cycle
Level of education: Master Degree Program
Period of completion: 2018/2019 and 2019 /2020 academic years

Form of presenting the work:

Master's Thesis

SCHEDULED ASSESSMENT CALENDAR
for the Master's Graduation Thesis completion

Deadline for completion of Master's Graduation Thesis:	

Assessment date	Title of section (module) / type of work (research)	Maximum score for the section (module)
28.01.2020	Preparation and approval of technical specifications	10
3.02.2020	Choosing the direction of research and ways to solve problems	10
17.02.2020	Collection and study of scientific and technical literature	10
9.03.2020	Design and simulation of the device's electrical circuit	20
6.04.2020	Manufacturing and testing of electrical circuits	10
6.05.2020	Analysis and processing of the results obtained	10
18.05.2020	Preparation for pre-defense of the FQW	15
8.06.2020	Preparation for the FQW	15

COMPILED BY:
Scientific supervisor

Position	Full name	Academic degree, academic rank	Signature	Date
Associate professor	Aleynik A.N	Ph.D		

Adviser

Position	Full name	Academic degree, academic rank	Signature	Date
Medical physicist Cancer Research Institute of Tomsk NRMC RAS	Turgunova N.D.			

AGREED BY:
Director of the programme

Position	Full name	Academic degree, academic rank	Signature	Date
Associate Professor	Cherepennikov Yu.M.	Ph.D		

TASK FOR SECTION
«FINANCIAL MANAGEMENT, RESOURCE EFFICIENCY AND RESOURCE SAVING»

For a student:

Group	Full name
0AM8M	Abdir Kulaikhan Shahatovna

School	School of Nuclear Science & Engineering	**Department**	Division for Nuclear fuel cycle
Degree	Master Degree programme	**Field of training /programme**	«Nuclear physics and technology/Nuclear Medicine»

Topic of research work:

Development of a digital ascultometer for the diagnosis of heart murmurs	
Input data to the section «Financial management, resource efficiency and resource saving»:	
1. Resource cost of scientific and technical research (STR): material and technical, energetic, financial and human	*Cost of raw materials* *The amount of salaries and payments to project performers*
2. Expenditure rates and expenditure standards for resources	According to the design documentation
3. Current tax system, tax rates, charges rates, discounting rates and interest rates	*Contributions to non-budgetary funds*
The list of subjects to study, design and develop:	
1. Assessment of commercial and innovative potential of STR	*Developing a competitive analysis*
2. Development of charter for scientific-research project	*Planning of work; building a hierarchical structure of the WRC*
3. Scheduling of STR management process: structure and timeline, budget, risk management	*WRC schedule – Gantt chart*
4. Determination of resource, financial, economic efficiency	*Evaluation of comparative and cost-effectiveness*
A list of graphic material *(with list of mandatory blueprints):*	
1. *"Portrait" of the consumer of the results of STR* 2. *Market segmentation* 3. *Evaluation of the competitiveness of technical solutions* 4. *FAST chart* 5. *SWOT- analysis* 6. *Gantt chart and budget of scientific research* 7. *Assessment of resource, financial and economic efficiency of STR* 8. *Potential risks*	

Date of issue of the task for the section according to the schedule	

Task issued by adviser:

Position	Full name	Academic degree, academic rank	Signature	Date
Assistant professor	Menshikova E.V.	PhD		

The task was accepted by the student:

Group	Full name	Signature	Date
0AM8M	Abdir Kulaikhan Shahatovna		

TASK FOR SECTION
«SOCIAL RESPONSIBILITY»

For a student:

Group	Full name
0AM8M	Abdir Kulaikhan Shahatovna

School	School of Nuclear Science & Engineering	**Department**	Division for Nuclear fuel cycle
Degree	Master Degree program	**Field of training /programme**	14.04.02 Nuclear Physics and Technology/Nuclear Medicine

Topic of research work:

Development of a digital ascultometer for the diagnosis of heart murmurs	
Initial data for section «Social Responsibility»:	
1. Information about object of investigation (matter, material, device, algorithm, procedure, workplace) and area of its application	The workplace is a computer table with a personal computer and an experimental device (digital auscultometer and its components: acoustic head, ECM-4F microphone, Atmega16 microcontroller, amplification and filtration unit, Board). Object of research – digital auscultated.
List of items to be investigated and to be developed:	
1. Legal and organizational issues to provide safety: – Special (specific for operation of objects of investigation, designed workplace) legal rules of labor legislation; – Organizational activities for layout of workplace.	– Sanitary Rules 2.2.2/2.4.1340-03. Hygienic requirements for PC and work with it
2. Work Safety: 2.1. Analysis of identified harmful and dangerous factors 2.2. Justification of measures to reduce probability of harmful and dangerous factors	Harmful environmental factors were identified: – Insufficient illumination of workplace – Excessive noise – Deviation of microclimate indicators – Electric shock;
3. Ecological safety:	- Analysis of the impact on the lithosphere: the formation of waste when a computer breaks down or is disposed of.
4. Safety in emergency situations:	– Fire safety;

Date of issuance of the task for the section according to the schedule	

The task was issued by adviser:

Position	Full name	Academic degree, academic rank	Signature	Date
Assistant professor	Verigin D.A.	Ph.D		

The task was accepted by the student:

Group	Full name	Signature	Date
0AM8M	Abdir Kulaikhan Shahatovna		

ABSTRACT

Master’s graduation thesis consists of 89 pp., 22 tables, 35 figures, 32 literatures, 1 appendix.

Keywords: phonocardiography, digital auscultated, physiological sounds.

The object of research is the developed auscultated for the analysis of physiologic sounds.

The aim of work is to create the layout of digital auscultate for heart and lung murmurs; study characteristics of the device.

In the process of research were carried out a mock-up of a digital auscultometer and software for analyzing the received data from the device were made, auscultation was performed on the received device, data on heart and lung sounds were obtained, and the characteristics of the auscultometer were measured.

As a result of the study the characteristics of the digital auscultate. The study of characteristics showed the effectiveness of the device in the diagnosis of the heart and lungs. The device clearly identifies sounds of various origins. The developed program allows you to make diagnostics based on the type of frequency spectrum.

Based on the results obtained, it is shown that the use of a digital auscultometer in the field of diagnostics gives such advantages as better sound, allows you to record and archive sound, can visualize sound, i.e. work as phonocardiographs, can receive additional information, such as ECG; high sensitivity and resolution, availability and low cost of components, therefore, this is an adequate and informative method for assessing heart and lung diseases. Studying the characteristics of the device has shown its effectiveness in the diagnosis of heart and lung diseases, so they complement and expand existing ideas about the possibilities of using the developed device for the diagnosis of heart and lung noise.

Application area: nuclear medicine, diagnosis of heart murmurs.

The final qualifying work was performed in the Microsoft Word 2013 text editor.

Content

Introduction

Among all diseases, cardiovascular diseases (CVD) occupy the leading positions in developed countries in terms of statistics on mortality, disability (1.2 categories) and disability. According to the world health organization, the death rate from this disease in the world is 31%, in Europe - 42%. However, lung diseases, including bronchial asthma (BD), are one of the most common chronic pulmonological diseases of childhood, so it is socially significant. The main cause of death from bronchial asthma and its course in a heavy stream is untimely diagnosis and improper treatment.

First of all, improving diagnostic methods is the most important measure of prevention of these diseases.

Currently, there are many methods for detecting diseases of the cardiovascular system. One of the main ones is auscultation. It is performed with a stethoscope by listening to the systole and diastole sounds coming from the corresponding points of the heart. In the human body, every second there is a lot of physiological processes (heartbeat, breathing, and so on), which are normally accompanied by various sounds. They are one of the most important indicators in assessing human health. Currently, the founder of used auscultation, Rene Laennec, developed the first stethoscope and made a great contribution to the development of this direction.

After listening to the heart signals, determining the heart pathology may be difficult for a doctor or a biomedical doctor, as other sounds or noises in the body interfere. In addition, a person cannot perceive heart balls visually or in the ear, and the heartbeat sound frequency is below 20 Hz, and the threshold for sound perception in humans is above 20 Hz. Therefore, the reliability of the method, the ability to understand the processes that are occurring, and evaluate them depends on the ability, experience, and knowledge of a specialist doctor to detect the disease.

In order to avoid the above-mentioned obstacles, an electronic stethoscope was invented, which uses a microphone to record organ noises, amplifies it several times and makes a person's ear heard by the ANFO. One of the main effects of this method is that the doctor can change the degree of sound amplification depending on the degree of hearing.for example, when helping a patient on a noisy street, you can use this tool to amplify the heart tones several times, so that you can hear even a very simple heartbeat. But a simple electronic stethoscope can't accept low-frequency sounds.

Due to the disadvantages of such a simple stethoscope, other improved tools have been invented to help detect and detect the disease. One such good method is phonocardiography (FKG). With the help of a special tool-a phonocardiograph, it displays the sounds of the heart in the form of an image. Thanks to this device, even imperceptible audio signals are detected and displayed on sliding paper or film. The effectiveness of the phonocardiograph is to divide the heart tones into parts corresponding to different sound frequencies, and then allows you to study them separately. If in a healthy heart high frequencies occur slightly (i.e. similar to musical sounds), then in a heart with the same defect there are swirling movements with a predominance of high frequencies. FKG for this reason is important in the diagnosis of PPE diseases.

The development of computational theses and personal computers allowed for the quantitative evaluation of various physiological sound images. It is possible to use new algorithms for viewing and processing audio signals as digital video. The main difference between phonocardiography and digital technology is that in this method, after recording, it is distributed by parameters and different frequencies can be divided into stages.

Despite these advantages, interest in this method, the use of the method in practice was not very common. Therefore, the scientific and practical basis is that the data of various sound manifestations of the body and the results of research. In this regard, the development of effective hardware and software and new technical devices, simplification of ausculation methods, and the study of physiological effects is one of the most popular problems at present. This is the simplicity in building requirements for these methods, informative and reasonable results in the prevention of lung diseases and PPE.

Chapter 1. Study of physiological sounds

1.1 Basic information about auscultation

Auscultation is one of the diagnostic methods based on sound representations that are listened to when certain organs are working. Natural physiological respiration occurs when breathing, with heart contractions in the lungs, and with narrowing of the intestines in the abdominal cavity. In many pathological changes, there is a change in these sounds or the appearance of new sounds.

When listening to a patient, in some cases, the doctor or patient may perform certain actions (speech, skin swelling, stress) and listen to sounds that occurred at this time. Basically, the sound frequencies that are listened to from various organs are equal to that of the sound signal received in the human ear (20-20000 Hertz). Most of these sounds are low-frequency noises between 20-5600 Hertz. Depending on this characteristic, low frequencies (20-180 Hz), medium frequencies (180-710 Hz), and high frequencies (710-1400 Hz) are classified. In addition to the frequency, it is also important to the sound hardness and duration. In addition, when auscultation is necessary to take into account the timbre of the sound, its tonal image, as this is very important when listening to the heartbeat [9].

The intensity of many natural and pathological sounds is not enough to propagate in the air. To do this, you must meet some conditions for listening to these sounds. Direct and indirect listening methods are used. The direct method of listening is listened to by hard touching the patient's body. This method allows you to hear sounds of sufficient hardness, but low-frequency sounds are not heard. In addition, this is an inefficient method for hygiene. Auscultation janma is carried out using special instruments – a stethoscope, electronic auscultator, the phonograph.

Auscultation is very important for detecting various heart and lung defects. When listening to different members, it should also be remembered that this happens in different ways, depending on the fact that the sounds and organs originating from them are located in different places.

1.2 Auscultation of the lungs

Auscultation occupies a special place in the study of the structure and function of the lungs. It can be used to listen to natural respiratory noises and altered sound noises for various pulmonary deficiencies. The anatomy of the chest and upper respiratory tract is shown in the figure 1 [10].

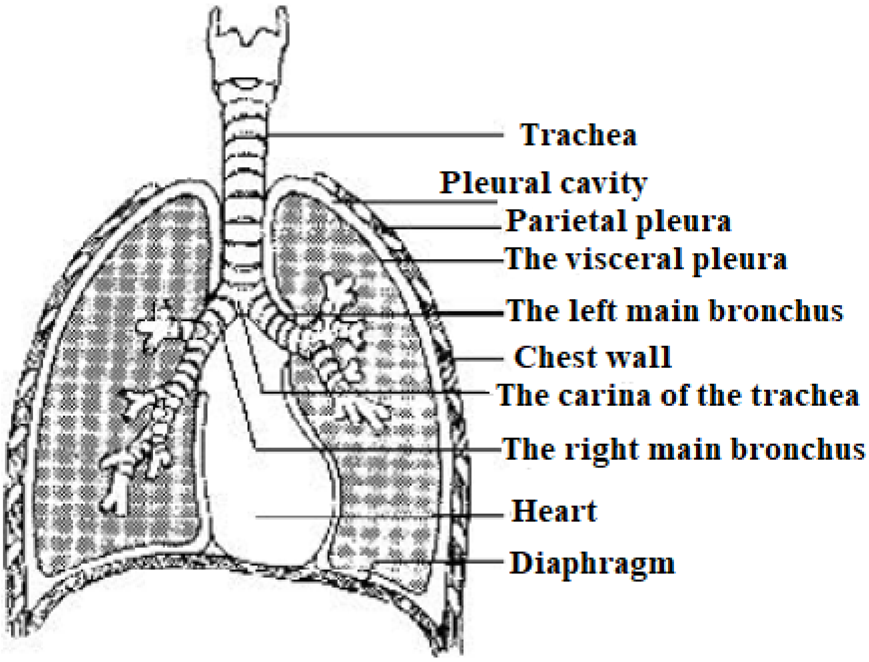

Figure 1. Anatomy of the chest and upper respiratory tract

Determined by auscultation of the lungs:

- Natural laryngotracheal;
- Normal and pathological bronchial, vesicular;
- Sound vibration;
- Altered respiratory noises.

The points that should be listened to are shown in figure 2.

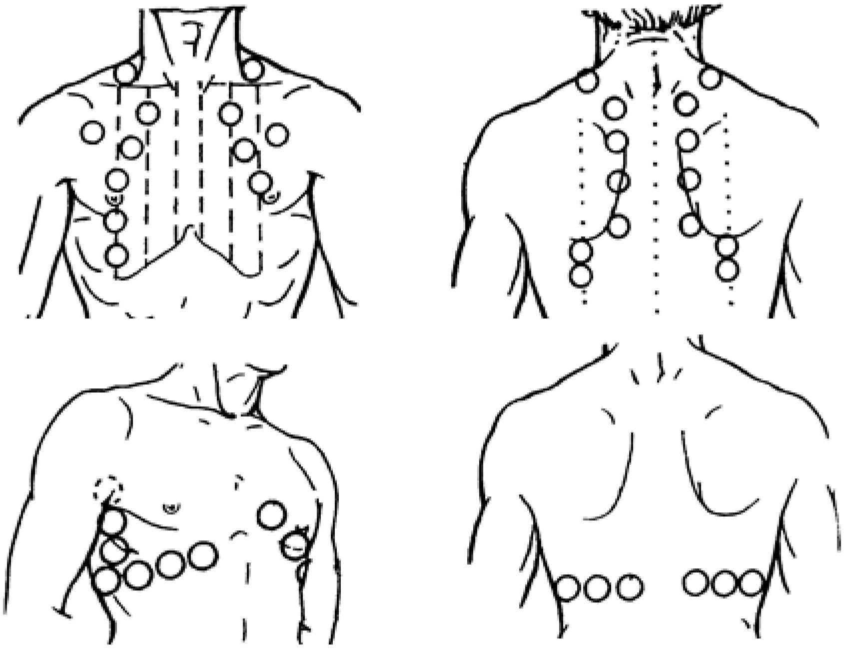

Figure 2. Designated mandatory auscultation of the lungs

Depending on the location of the main respiratory noises, such as natural and pathological noises, are evaluated depending on the volume, total duration, and the ratio of respiration and respiration.

Additional respiratory noises are described depending on the location indicating (right, left) side of the chest, indicating intercostal zones, lines of location, stiffness, height, timbre, relative to the stages of breathing, changes in deep breathing, false breathing, after coughing changes [11, 12].

Laryngotracheal breathing

Airways and breathability are accompanied by changes in the speed of movement, the appearance of various currents. All of the above leads to changes in the dense structures of the respiratory tract and alveoli, the appearance of sound waves propagated through the bronzial tree to the chest, part of which is lost along this path.

During rest, the movement of air through the mouth and nose does not show clear sounds. A number of sounds appear at the narrowing point of the first natural sound tube-at the level of the sound hole. The air when passing through a narrow opening sets in motion the sound bundles. Here, the rotating streams turn into sound in the smooth-walled larynx and trachea. Certain sound phenomena occur when the air flow touches the wall of the bronchi and trachea. Sounds formed in the zone of the sound hole are not listened to by the ear at a certain distance, but are easily listened to through a phonendoscope installed in the thyroid cartilage of the larynx, trachea and larynx. These sounds are called "laryngotrachial breathing" [11, 12].

During breathing, the sound hole expands, and there are fewer rotating streams. Therefore, the sounds you listen to will be quiet and short. And when you breathe, the sound hole expands and grows in the rotating stream, so when you breathe, the sound sounds loud, rough, and longer. The ratio of the duration of laryngotrachial respiration and respiration is 4:5, and when listening, it is similar to the sounds of "HA" or "HE" (see figure 3, a).

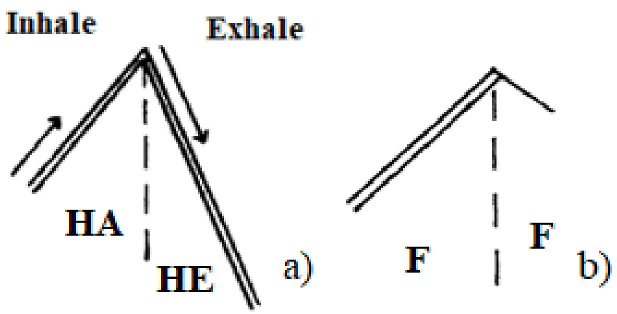

Figure 3. Graphic image of the lungs: a-for laryngotracheal respiration; b-for vesicular respiration

Laryngotracheal sounds heard in remote places of the trachea, passing through the bronchial tubes, called natural bronchial breathing. Are the breath sounds during normal breathing [11, 12].

Physiological vesicular respiration

Visicular sound is formed from the alveoli from changes developing in the end branches of the respiratory tube with repeated cutting of the sound wave and due to the overflow of the walls with air and the release of air. This noise sounds like a gentle, continuous, uniform, similar to the sound of quot; Fquot;, a soft purge sound. At the same time, the sound is also heard in 2 stages of sound, in the breath it is more obvious in its rigidity and duration. This is due to the activity of breathing – the decline of the respiratory muscles, the opening of the sound hole, air filling with alveoli, stretching and tension of its walls. And for the inactive period, that is, the breathing noise is weak and short. The duration of breathing when listening is more than 2 times longer than the expiration. During the fallout period, the respiratory muscles relax, the sound hole narrows, and the air flow rate quickly decreases, so 2/3 of the airway passes without sound. The image of a normal visicular is shown in figure 3, b. [10, 11, 12].

Bronchophonia

Voice vibration is a method that is listened to using a phonendoscope from the surface of the chest. Sound vibrations that appear in words spread from the larynx, the air column and the bronchial tree to the extreme area, to the outer surface of the chest [10].

Additional (indirect) respiratory noises

Additional Airways-pleural cavities, Airways, alveoli. They can give information about the disease only in small cases.

Additional Airways include: wheezing, trepitation, pleural friction noise, and pleuropericardial sutures.

1.3 Analysis of heart sounds

In the process, the heart muscles and valves produce colorful sounds. Analysis of these sounds provides valuable information about the state of the heart.

During auscultation, the tasks assigned depend on the state of the patient's movement. As a rule, the heart listens when the patient is in an upright position: sitting or standing. The heart should be listened to when the patient is breathing, when half-breathing for 10-20 seconds, and when breathing fully. This method should be repeated several times after a short rest (3-4 breaths). Holding your breath is necessary to avoid noises in the heel that prevent you from listening to your heartbeat. The places where the heart is listened to are shown in figure 4 [11].

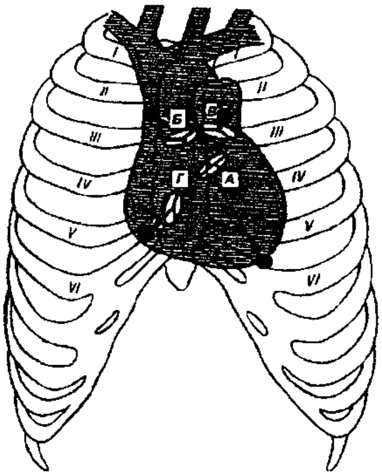

Figure 4. Projection of heart valves on the chest wall and their listening points. A-mitral valve; B-aortic valve; C-pulmonary trunk valve; D-tricuspid valve

1.3.1 Phonocardiography

Phonocardiography is a method of graphic recording of heart tones and noises, which are always detected during auscultation. When hearing, you need to know the features of heart sounds, and the hearing ability of the doctor has a certain value. Phonocardiography allows for qualitative and quantitative analysis of heart tones and noises.

When the movement of blood through the vessels, the motion of the valves, when the contraction of the heart are formed of different turbidity. Coupling between them is called sound. Vibration with a frequency of 6-10 vibrations (i.e. 6-10 Hertz) is not a sound source and is not heard by the ear. To obtain the sound effect you need to have dozens or even hundreds of tarbela per second. If you put a device in the chest in the heart area that turns mechanical vibrations into electrical vibrations, we will get a graphic image of the signal [13, 14].

Sounds are divided into vibrational, wave movements that propagate in various environments: in the air, on liquid and solid bodies, in the tissues of a living organism.

The volume of audibility of heart tones lies in a wide range-from the unheard ear to intense sounds. There are three types of sounds according to the type and nature of the sound wave:

– Sound impacts that occur when shots are fired, when an explosion occurs, when heavy bodies are struck, and so on. The shock wave that corresponds to these sounds is a uniform wave wave;
– The source of sound or musical sounds that occur in the periodic terbelisinen fur coat. They consist of a series of the following waves of the same length and shape;
– Chain periodic, not bits representing the oscillation noises. [13, 14].

The intensity of noise and tone is determined by the amplitude of vibrations that make up the sound. The subjective assessment of noise and tone intensity does not coincide with the objective assessment of sound intensity. This is due to the features of the human auditory analyzer. Human auditory analyzer from 16 to 20000 Hz-vibration takes on sound. The reception limit is 16 Hz. Vibrations from 1 to 16 Hz are infrasounds. They are below the limit of hearing and do not hold the ear. Frequency characteristics of heart and speech sounds are shown in figure 5. Vibrations of different frequencies correspond to different frequencies of tones: the higher the frequency of vibrations, the higher and the lower the frequency of vibrations, the fewer tones. Most sound vibrations, based on sounds and noises, are beyond the limits of sound perception. Therefore, phonocardiography is important, which allows recording sound vibrations outside the ear's perception [15, 16].

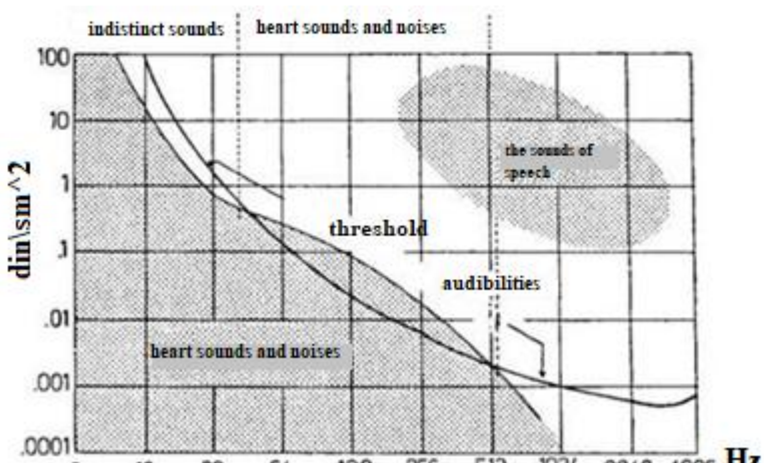

Figure 5. Frequency characteristics of heart and speech sounds. On the axes-on the abscissa frequency, on the ordinate-the volume of sound

When evaluating a phonocardiogram, listening gives a different result than a heart phonogram performed with a linear microphone and amplifier. Because these are filters of the human ear and chest. If you assume that the heart creates a spectrum of tones, such as white noise (in other words, the amplitudes of the components are the same with different frequencies), then you can expect that even on the outer surface of the chest receive a spectrum of frequencies. In fact, this is not the case. The walls of the chest, as well as the tissues surrounding the heart, act as a low-frequency filter (Fig. 6). Consequently, the current amplitude on the chest surface decreases sharply as their frequency increases [15].

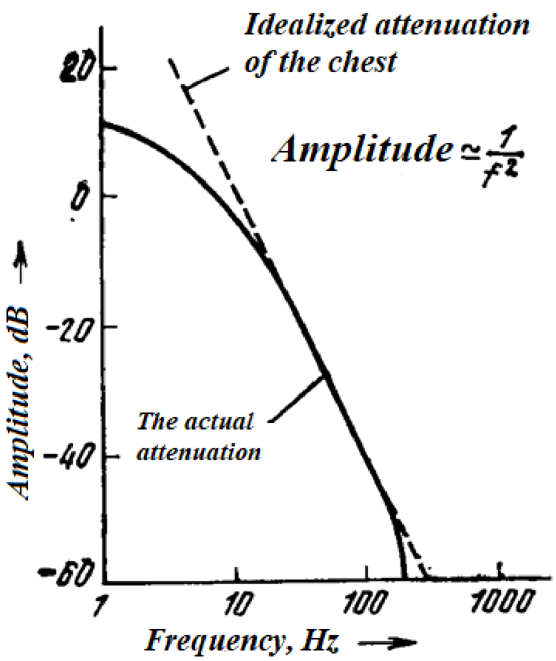

Figure 6. Frequency characteristics of the chest wall and tissues surrounding the heart

This distortion does not occur during listening, since the frequency response of the human ear is uneven. For a human ear of approximately 2-3 kHz, the sensitivity increases with increasing frequency. In the frequency range of heart tones, this relationship is the opposite in comparison with the frequency characteristic of the chest. As a result, the doctor hears the heart tones without distortion. The description of people's ear perception is given in figure 7. In this phonocardiography, it is possible to ensure that the lower and upper heart tones are equally represented by using frequency filters, making artificial distortion [16].

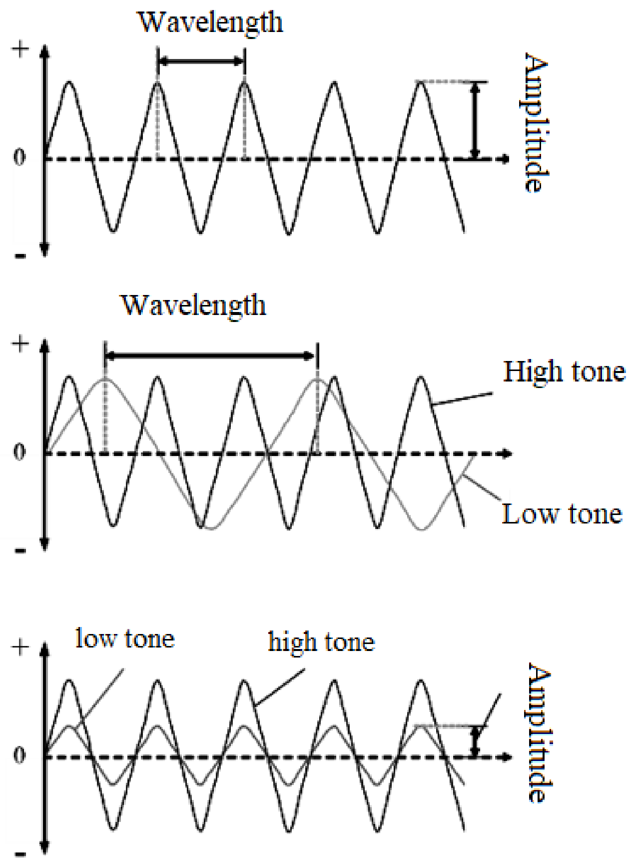

Figure 7. Dependence of human hearing on sound parameters: dependence on the frequency and amplitude of sound waves

1.3.2 Heart eones and their graphical representation

In the work of the heart, there are always changes in the pressure in its cavities and large vessels, as a result of which the heart valves are closed. When the ventricles bleed, the work of the valves, the hardening of muscle structures and large vessels form the corresponding vibrations that when listening to the heart tones. Basically, these sounds are not sounds, but oscillatory noises of different frequencies, not periodically. In experimental terms, it is preferable to call them sounds, since we know the difference between noises in heart tones and heart defects [17].

When auscultation of the heart, 4 different tones are distinguished,but at the tips of the heart and on the basis of the seven-sided plant, two tones are listened to, when the first is heard primarily (Fig. 8).

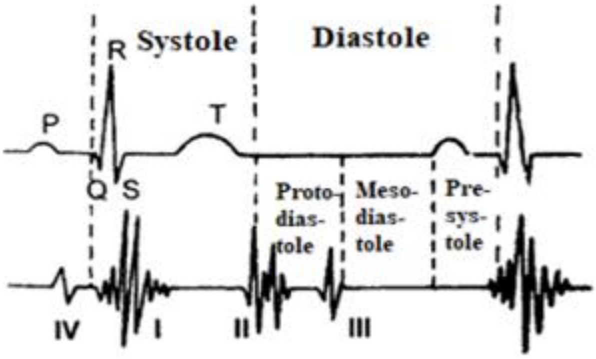

Figure 8. Synchronous recording of ECG and FKG. Phases of cardiac activity and heart tones

The first and second tones are separated by silent stages: systole - silent release of blood from the ventricle and diastole-silent filling of the ventricles. The first stage is short, the second– 1/3 – 1/2-and more than the first stage. The difference in the duration of systole and diastole depends on the heart rate, the difference between them is less than the heart rate.

The first, hard syllable corresponds to the first tone. The first tones appear at the beginning of the stomach systole after a long break. Therefore, it is called systolic. Its duration is 0.09-0.12 s, which is due to the lower timbre, systolic tension of the left ventricle and the surface location of the end than the chest of the urogenital process. At the top of the heart, than the first tone of the xiphoid process [17].

When listening to the heart on the second intercostal basis after a short auscultative break (ventricular systole), 2 tones are heard to the right and left of the sternum edge, but it sounds loud with a blow to the second joint.

The second syllable link corresponds to the second syllable. The second sound occurs in the initial stage of relaxation of the heart, so it is called diastolic sound. This is short compared to the first tone (0.05-0.07 sec.) and an increase (Fig. 9).

The second tone is heard on the aorta and the pulmonary artery, but the pressure on the pulmonary artery is much lower than the aorta. The same audibility of these sounds is associated with the inclination of the valves of the pulmonary artery, that is, with the location closer to the chest cavity, and the aortic valves more distant from it [17].

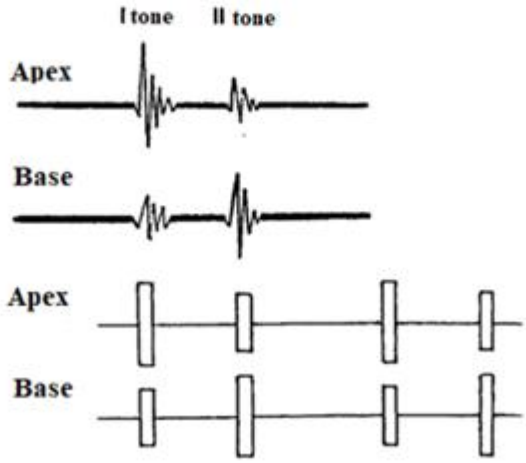

Figure 9. Phonocardiogram and diagram of normal tones when listening at the top and at the base of the heart

The main signs of normal heart tones are shown in table 1.

Table 1. Main signs of normal heart tones

Signs	I tone	II tone	III tone	IV tone
The best place of the hearing	Apex	Base	Apex or closer to the sternum	Apex
Relation to cardiac phases	Occurs at the beginning of systole after a large auscultative pause after diastole	Occurs at the beginning of diastole after a small auscultative systole	Occurs at the beginning of the diastole shortly after the II tone	Occurs at the end of the diastole before the I tone
Duration	0,09-0,12 s	0,05-0,07 s	0,03-0,06 s	0,03-0,10 s
Frequency response	30-120 Hz	70-150 Hz	10-70 Hz	70-100 Hz
Auscultative characteristic	Loud, low, long, louder at the apex	Loud, high, short, louder at the base	Quiet, deaf, low, short	Quiet, deaf, low, short

1.3.3 Mechanisms of heart tones

The appearance of each tone in the heart, there are various processes: the contraction of the myocardium, the movement of the valves, blood secretions, all these give various sound effects that make up the tones. Knowledge of the mechanism of tone formation helps to correctly analyze the received phonogram [16].

The appearance of the first tone has three factors:

- When all the valves are closed, during the period of isometric compression of the ventricles, depending on the fluctuations of the edge of the two-leaf and three-leaf valves;
- Depending on the fluctuations of the ventricular muscles, the pepper of the nipple-muscles, the chord at isometric amplification;
- Depending on the initial fluctuations of the aortic and pulmonary arteries when blood is released from the ventricles. In some literatures, the appearance of the first tone also includes atrial vibrations that contract.

In some literatures, the appearance of the first tone also includes vibrations of the cores.

The second tone is formed when bleeding from the ventricles and vessels during relaxation, when closing the aortic and pulmonary valves during initial relaxation of the heart. A small role in the appearance of the second tone is acquired by the vibration of the aorta and pulmonary artery, which develops due to repeated bleeding (figure 10).

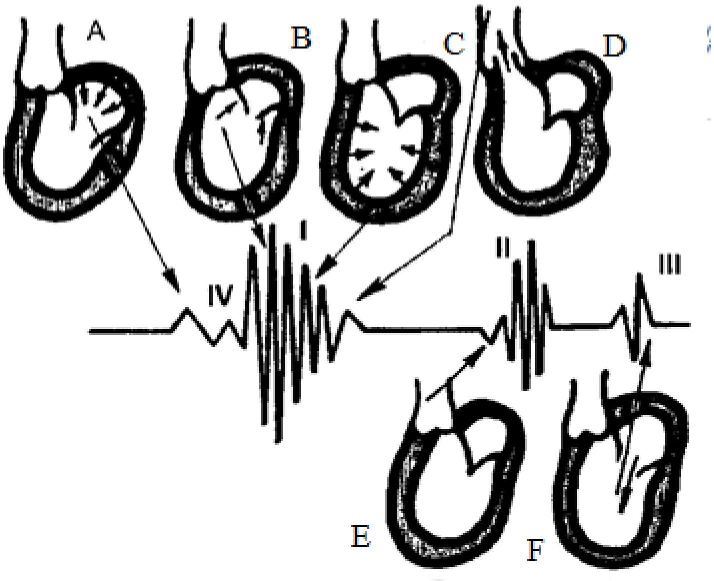

Figure 10. Scheme of heart tone formation: A – atrial component (IV tone); B – valvular component of I tone; C – muscular component of I tone; D – vascular component of I tone; E– mechanism of formation of II tone; F – mechanism of formation of III tone.

The physiological third tone is heard in children of asthenic type, adolescents, and youth. This sound is heard after the second sound (after 0.12-0.15 seconds). It is located in the protodiastole and is perceived as an echo.

The third tone is formed from vibrations that develop at the beginning of diastole due to rapid and passive hemorrhage of the ventricles of the heart. The main condition for the appearance of the third tone is a high tone and elasticity of the myocardium in children and young people (figure 11).

The dark third tone is lower, it is quiet and short (0.03-0.06 s). The third tone is heard at the tip of the heart and in the area of absolute cardiac dullness, usually better, but within 1-3 seconds after the transition from standing to lying position. Sometimes it can be heard in the patient lying down with deep breathing or in the position of lying on the left side. In a standing position, the third tone is very rare [17].

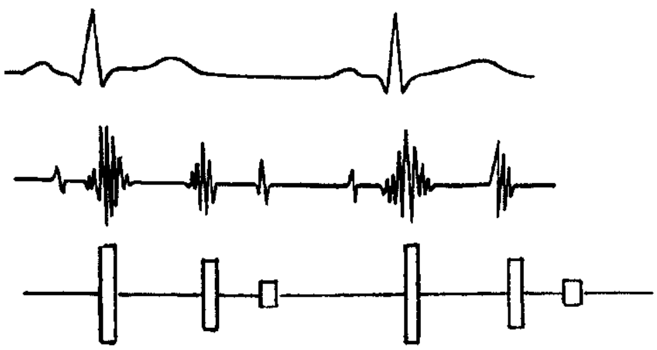

Figure 11. Graphical representation of the third physiological tone

The physiological fourth tone is even rarely heard in adolescents and young people. It is formed after atrial contraction with rapid ventricular bleeding and is associated with the vibration of the ventricular walls, which has a high tone and good elasticity. The fourth tone sounds good when breathing, lying down. The listening area is the tip of the heart. The fourth tone has a short (0.03-0.01) and quiet sound, heard before the first tone at the end of the diastole. The graphic fourth physiological tone is shown in figure 12 [17].

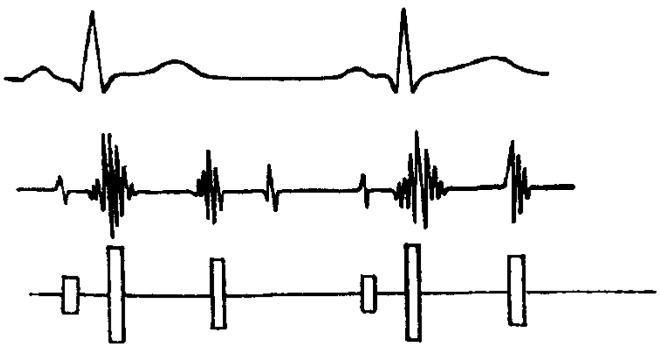

Figure 12. Physiological fourth tone.

1.3.4 Heart Murmurs

In phonocardiography, special attention is paid to noise recognition, since they receive a lot of information, some of which do not give the power to distinguish a person's auditory abilities. Noise is divided into functional and organic heart noises.

Functional noise is usually generated on an undamaged heart valve apparatus. They are often observed in children suffering from anemia, baseda's disease, asthenic bodies, people with a weakened nerve, and sometimes in completely healthy people in the case of arousal. Functional murmurs are systolic and are often well heard at the apex of the heart and on the pulmonary artery. They occur as a result of tachycardia, impaired capillary muscle function, or stretching of the left atrioventricular valve ring. Sometimes functional noises are also diastolic. For example, if the aortic valve is insufficient at the end of the heart, a functional diastolic noise (flint noise) can be heard, associated with the formation of functional stenosis of the left atrioventricular opening due to increased flaps of the left atrioventricular valve [17].

In the heart, and auscultation, are determined by noise of varying strength and duration of the FCG. In some cases, they are not obvious, and in others they may be obvious. In FKG, you always need to estimate the noise amplitude. Figure 2.7 shows that in this diploma project, the diploma project presented a project that was implemented as part of the project. They are called noise of large (high) amplitudes. Usually, high amplitude noises are characteristic of organic damage to the valvular apparatus of the heart. During auscultation, they are assessed as intense. Such noises can often be organic, but functional. Noise of low intensity is called the amplitude of vibrations less than half the amplitude of the I tone. In most cases, they are functional, but may be organic, especially if the noise is diastolic.

Classification of noise by hemodynamic origin:

- noise output;
- systolic functions of the stomach: aortic stenosis and pulmonary artery stenosis;
- mitral and tricuspid stenosis;
- reverse current balls;
- systolic stomach: mitral and tricuspid insufficiency, ventricular septal defect;
- diastolic stomach: insufficiency of the aortic and pulmonary valves;
- noise filling, i.e. diastolic;
- diastolic ventricles: mitral and tricuspid stenosis;
- presystolic sutures in mitral stenosis (Fig. 13).

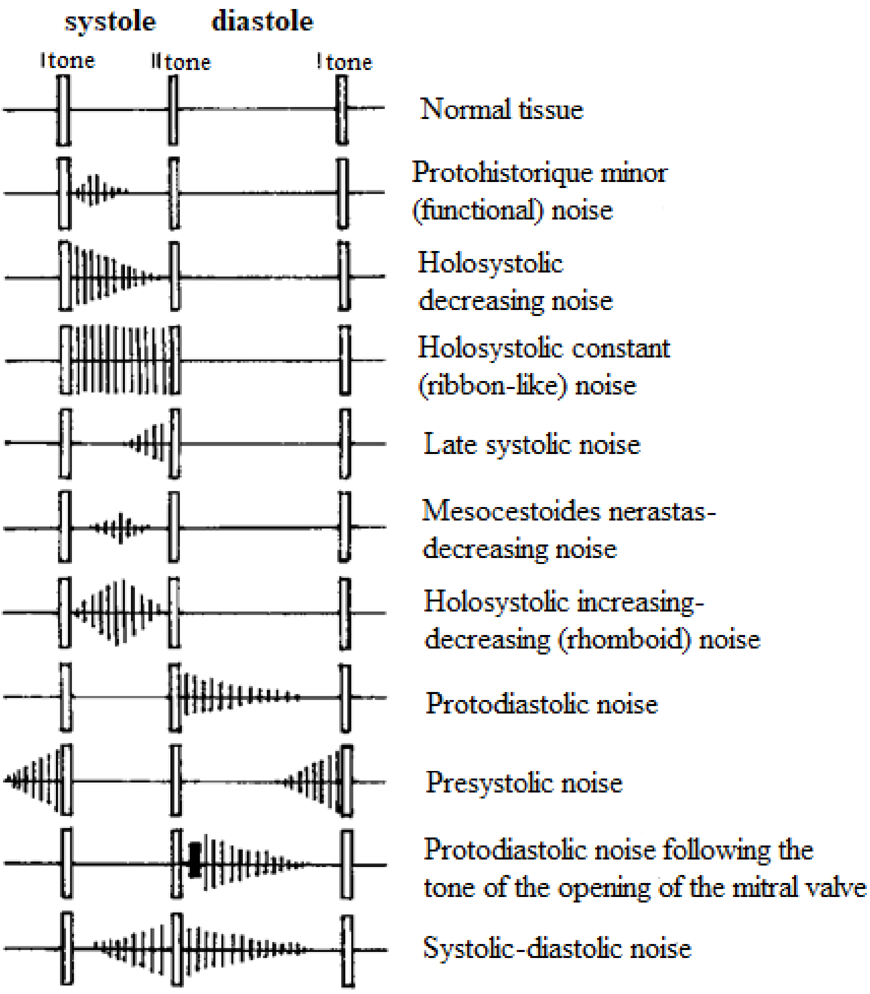

Figure 13. Variants of systolic and diastolic noise

Also today, there is a database of recorded phonograms, which can be used to compare patient indicators. By adding new data to this database, you can use it more effectively if you develop special software for automatic diagnostics. But do not forget that this is not a trivial task, since for a correct diagnosis it is not enough to know the type of signal received, as well as to take into account the individual characteristics of each person being examined. However, the development and further development of such technical systems will allow auscultation to move to a qualitatively new level [17].

Chapter 4. Financial management, resource efficiency and resource conservation

The prospects of scientific research are determined not only by the importance of the work done, but also not in a small degree depends on the commercial significance. Based on this, the pre-project analysis should also take into account the economic aspects of the work performed. Analysis of the economic side of the project will help to optimally allocate resources and coordinate the progress of the work. In turn, through this assessment, the developer can find a partner for further research and provide the research product to the market [28].

Similarly, the purpose of this section is to determine the prospects and well-being of a scientific project, create a management mechanism and control the stages of implementation. It presents the results of the following stages of scientific project management:

1. Project initiation.
2. Planning of the project.
3. The execution of the project.

These stages are preceded by a pre-project analysis aimed at collecting information describing the requirements for the product or service.

4.1. Pre-project analysis

4.1.1. Potential consumers of research results

To segment the market to develop a digital auscultate possible on the criterion of customer type. The consumer can be a scientific laboratory, healthcare and educational institutions, and individuals.

Consumer	Digital auscultometer and software
Scientific laboratory	+
Health/educational institutions	+
Natural person	+

Figure 35. Map of market segmentation

Based on the results of segmentation, figure 35, the main segments of this market are identified. Since the end product of this research is a digital auscultometer and software designed to process audio signals received from other similar devices, the market segments of this product include a scientific laboratory for testing devices; as well as individuals and health/educational institutions that use the device to diagnose disease.

4.1.2. Analysis of competitive technical solutions from the point of view of resource efficiency and resource saving

Analysis of competitive technical solutions from the point of view of resource efficiency and resource saving.

Evaluation of competitive technical solutions from the point of view of resource efficiency and resource saving allows us to analyze the comparative effectiveness of scientific development and determine directions for its future improvement. This analysis was carried out using the evaluation map, which is shown in table 3. B – the product that is the result of this work, $B_{к1}$ and $B_{к2}$ – competitive developments.

The position of developers and competitors is evaluated for each indicator by experts on a five-point scale, where 1 is the weakest position, and 5 is the strongest. The weights of indicators determined by expert means should total 1. The analysis of competitive technical solutions is determined by the formula (4.1.):

$$K = \sum W_i \cdot B_i \qquad (4.1.)$$

Where, K– the competitiveness of a scientific development or competitor;

W_i – the weight of the indicator (in fractions of a unit);

B_i – the score of the i-th indicator.

Table 3. Evaluation map for comparison of competitive technical solutions (developments)

Evalution criteria	Criterion weight	Points			Competitiveness		
		B	$B_{к1}$	$B_{к2}$	K	$K_{к1}$	$K_{к2}$
Technical criteria for evaluating resource efficiency							
Improving user productivity	0,1	5	5	5	0,5	0,5	0,5
Convenience in operation	0,05	5	4	5	0,25	0,2	0,25
Energy efficiency	0,05	5	4	4	0,25	0,2	0,2
Reliability	0,05	4	5	5	0,2	0,25	0,25
Noise level	0,1	3	5	4	0,3	0,5	0,4
Safety	0,05	5	5	5	0,25	0,25	0,25
Functional capacity (provided features)	0,2	5	5	4	1	1	0,8
Easy operation	0,05	5	4	4	0,25	0,2	0,2
Ability to connect to a computer network	0,1	5	5	5	0,5	0,5	0,5
Economic criteria for performance evaluation							
The competitiveness of the product	0,05	4	5	5	0,2	0,25	0,25
The level of market penetration	0,05	0	5	5	0	0,25	0,25
Price	0,05	5	3	3	0,25	0,15	0,15
After-sales service	0,1	5	4	3	0,5	0,4	0,3
TOTAL:	1				4,45	4,65	4,3

The main advantage of the digital auscultometer developed within the framework of the master's thesis is its ease of use, which makes it possible to improve the effectiveness of diagnosing heart and lung diseases in the field of medicine, reliability and availability of the device. While competitive developments are narrowly focused and more expensive.

4.1.3. SWOT-analysis

SWOT analysis – (Strengths, Weaknesses, Opportunities, Threats) – is a comprehensive analysis of a research project. SWOT analysis is used to study the external and internal environment of the project. It is carried out in several stages.

The first stage describes the strengths and weaknesses of the project, identifies opportunities and threats to the implementation of the project that have appeared or may appear in its external environment.

The second stage is to identify the compliance of the strengths and weaknesses of the research project with external environmental conditions. This correspondence or discrepancy should help identify the extent to which strategic changes are needed. During this stage, an interactive project matrix is built (table 4). Using it helps you understand different combinations of relationships between areas of the SWOT matrix. It is possible to use this matrix as one of the bases for evaluating strategic choices. Each factor is marked with either a "+ "sign (meaning a strong match of strengths to capabilities) or a" - " sign (meaning a weak match); "0" – if there is doubt about whether to put a "+" or "-".

Table 4. Interactive project matrix

		The strengths of the project				
		C1	C2	C3	C4	C5
The possibilities of the project	B1	0	+	0	0	+
	B2	+	+	+	+	+
	B3	+	+	0	0	+
	Weaknesses of the project					
	C1	C2	C3			
Project threats	У1	+	+	+		
	У2	-	-	-		

In the second stage, the final SWOT analysis matrix was compiled, which is shown in table 5.

Table 5. Final SWOT analysis matrix

	Strengths of the research project: S1. Simplicity of the device S2. Possibility to use the device for diagnostics of equipment S3. Open source code S4. Possibility of improvement by the consumer S5. Lower cost of production compared to other technologies	Weaknesses of the research project: W1. Unattractive design W1. Lack of a prototype of scientific development W3. Lack of an engineering company that can build turnkey production
Opportunities: O1. Public financing O2. Additional demand for a new product O3. Increasing the cost of competitive development	Need to show customers the simplicity of the device and open source code as an advantage. Make certain configurations so that the buyer can choose the one that suits them (for example, for listening to the heart, lungs for diagnosing equipment)	The development of digital auscultometer contributes to the increasing demand for competitive methods in medicine
Threats: Th1. Developed competition of production technologies Th2. Introduction of additional state requirements for product certification	Certification of the developed methodology. Obtaining a patent for a utility model. Implementation of the developed methodology in research laboratories.	Should improve the characteristics, especially over the appearance, and make it more convenient. Emphasize the advantages, since there is no prototype of scientific development.

4.1.4. Assessment of the project's readiness for commercialization

At whatever stage of the life cycle of a scientific development, it is useful to assess the degree of its readiness for commercialization and find out the level of your own knowledge for its implementation (or completion). To do this, you need to fill out a special form containing indicators on the degree of development of the project from the point of commercialization and the competence of the developer of the scientific project. The table for evaluating the project's readiness for commercialization is shown in table 6.

When analyzing the table, each indicator is rated on a five-point scale. At the same time, the measurement system for each direction (the degree of elaboration of the scientific project, the level of knowledge available to the developer) differs. Thus, when assessing the degree of elaboration of a scientific project, 1 point means that the project is not well developed, 2 points – weak elaboration, 3 points – completed, but not sure of the quality, 4 points – performed qualitatively, 5 points – there is a positive conclusion of an independent expert. To assess the level of knowledge available to the developer, the points system takes the following form: 1 – do not know or know little, 2 – in the amount of theoretical knowledge, 3 – know the theory and practical examples of application, 4 – know the theory and independently perform, 5-know the theory, perform and can advise.

Assessment of the readiness of a scientific project for commercialization (or the level of knowledge the developer has) defined by the formula:

$$B_{sum} = \sum B_i, \qquad (4.2.)$$

where B_{sum} – the total number of points in each direction; B_i -the score for the indicator.

The B_{sum} value indicates the degree of readiness of a scientific development and its developer for commercialization. So, if the value of B_{sum} is from 75 to 60, then this development is considered promising, and the developer's knowledge is sufficient for its successful commercialization. If from 59 to 45, the prospects are higher than average. If from 44 to 30, the prospects are average. If from 29 to 15, the prospects are lower than average. If 14 and below, the prospects are extremely low.

Table 6. Form for evaluating the degree of readiness of a scientific project for commercialization

№ п/п	Title	The degree of elaboration of the scientific project	The developer's level of knowledge
1.	The available scientific and technical reserve is defined	4	4
2.	Promising areas of commercialization of scientific and technical potential have been identified	3	5
3.	Identified industries and technologies to offer on the market	5	5
4.	The commodity form of the scientific and technical reserve for submission to the market is defined	4	5
5.	Authors were identified and their rights were protected	2	3
6.	An assessment of the value of intellectual property was made	2	3
7.	Marketing research of sales markets was conducted	4	4
8.	A business plan for commercialization of scientific development has been developed	3	4
9.	The ways of promotion are defined scientific development on the market	3	3
10.	The strategy (form) of scientific development implementation has been developed	3	3
11.	Issues of international cooperation and entering the foreign market have been worked out	1	2
12.	The issues of using the support infrastructure services and receiving benefits have been worked out	2	2
13.	The issues of financing commercialization of scientific development have been worked out	2	2
14.	There is a team for commercialization of scientific development	3	4
15.	The mechanism of implementation of the scientific project has been developed	2	4
	TOTAL POINTS	**43**	**53**

Based on the results of the table, we see that the value of B_{sum} is 43 and 53, which indicates that the developer's prospects and knowledge are above average.

4.2. Project initiation

The initiation process group consists of processes that are performed to define a new project or a new phase of an existing one. As part of the initiation processes, the initial goals and content are defined and the initial financial resources are recorded.

Internal and external stakeholders of the project are identified, which will interact and influence the overall result scientific project. This information is fixed in the project Charter.

The project Charter documents the business needs, current understanding of the project customer's needs, and a new product, service, or result that is planned to be created.

The Charter of the master's research project should have the following structure:

Project goals and results

In this section, you should provide information about the project's stakeholders, the hierarchy of project goals, and criteria for achieving goals.

Stakeholder of the project is the Department of pension Fund of physical and technical Institute of Tomsk Polytechnic University.

In the table 7 provides information about the hierarchy of project goals and criteria for achieving goals.

Table 7. Project goals and results

Project of project:	The development of digital auscultate and its study
Expected result of the project	Get a ready-made device and research results
Criteria for acceptance of the project result:	Develop a device for auscultation
Requirements for the project result:	Efficiency
	Speed
	Informativity
	Not a high cost

Organizational structure of the project

At this stage, the following issues were resolved: who will be included in the working group of this project, determine the role of each participant in this project, and specify the functions performed by each of the participants and their labor costs in the project. This information is shown in table 8.

Table 8. Organizational structure of the project

№ п/п	Participant	Role in the project	Functions	Labor time, hours
1	Aleynik Alexander Nikonorovich, department nuclear fuel cycle, SNSE SR TPU, Ph.D	Project manager	Coordinating the activities of the project executor	240
2	Abdir Kulaikhan Shahatovna, department nuclear fuel cycle, SNSE SR TPU, undergraduate	Project executor	Performing individual works on the project	360
TOTAL:				**600**

4.3. Planning of scientific and technical project management

A group of planning processes consists of processes that are performed to determine the overall content of work and develop a sequence of actions required to achieve these goals.

4.3.1. Project plan

Table 9. Project schedule

Код работы	Название	Длительность, дни	Дата начала работ	Дата окончания работ	Состав участников
1	Getting a task and theoretical review of the literature on the subject of the study	20	09.01.2020	31.01.2020	Abdir K.Sh..
2	The choice of direction of research	5	01.02.2020	06.02.2020	Aleynik A.N., Abdir K.Sh.
3	Drawing up a research plan	2	7.02.2020	09.02.2020	Aleynik A.N., Abdir K.Sh.
4	Design the layout of digital auscultometer	33	10.02.2020	23.03.2020	Aleynik A.N., Abdir K.Sh.
5	Creating a program in a PC for data processing and testing the device	20	24.03.2020	15.04.2020	Aleynik A.N., Abdir K.Sh.
6	The study using the developed digital of auscultometer	9	16.04.2020	25.04.2020	Aleynik A.N., Abdir K.Sh.
7	Analysis and processing of the results obtained	7	27.04.2020	08.05.2020	Abdir K.Sh.
8	Making an explanatory note	12	12.05.2020	26.05.2020	Abdir K.Sh.
9	Preparing for defense	10	27.05.2020	06.05.2020	Abdir K.Sh.

The Gantt chart is the most convenient and visual way to represent the work schedule. To build a Gantt schedule, you should translate the duration of each of the work performed into calendar days.

The conversion of the duration of each stage from working days to calendar days is performed using the following formulas 4.3 and 4.4:

$$T_{ci.ex1.} = T_{wi} \cdot k_{cal} \quad (4.3)$$

$$T_{ci.ex2.} = T_{wi} \cdot k_{cal} \quad (4.4)$$

Where, T_{ci}– duration of the i-th work in calendar days; T_{wi} – duration of the i-th work in working days; k_{cal}– calendar coefficient.

The calendar factor is determined by the following formula 4.5 and 4.6:

$$k_{cal.ex1} = \frac{T_{cal}}{T_{cal} - T_{off} - T_{hol}}, \qquad (4.5)$$

$$k_{cal.ex2} = \frac{T_{cal}}{T_{cal} - T_{off} - T_{hol}} \qquad (4.6)$$

Where, T_{cal} – the number of calendar days in the year; T_{off}– the number of days off in the year; T_{hol}– the number of holidays in the year.

The calculation of labor intensity and duration of work is presented on the example of the work «Preparation and approval of technical specifications»:

$$t_{\exp i} = \frac{3t_{\min i} + 2t_{\max i}}{5} \qquad (4.7)$$

Where, $t_{\min i}$– the minimum possible time the task performer (an optimistic estimate: at successful coincidence of circumstances), pers.-days;

$t_{\max i}$–the maximum time the task performer (is a pessimistic estimate: in case of unsuccessful combination of circumstances), person-days.

Based on the calculations of the expected labor intensity of the work, it is necessary to determine the duration of each work in working days T_w :

$$T_{wi} = \frac{t_{expi}}{P_i} \qquad (4.8)$$

Where, P_i - is the number of performers simultaneously performing the task, people.

Calculating the calendar coefficient for a five-day work week for an executor2:

$$k_{cal.ex2} = \frac{\mathrm{T}_{cal}}{\mathrm{T}_{cal} - \mathrm{T}_{week} - \mathrm{T}_{hol}} = \frac{365}{365 - 104 - 14} = 1{,}48 \qquad (4.9)$$

The calculation calendar of the duration of the work on the example project "Design of digital auscultometer»:

$$\mathrm{T}_{ci.ex2} = T_{wi} * k_{cal} \qquad (4.10)$$

Calculation of the calendar coefficient for the six-day working week of the executor1:

$$k_{cal.ex1} = \frac{365}{365 - 52 - 14} = 1{,}22 \qquad (4.11)$$

All calculated values in calendar days, rounded to the nearest whole number, are then summarized in table 10.

Table 10. Time indicators of RS

Work name	Labor intensity of work			Executors	Duration of work in working days $T_{w\ i}$		Duration of work in calendar days $T_{c\ i}$
	t_{min}, person-days	t_{max}, person-days	$t_{\exp i}$, person-days				
Getting a task and theoretical review of the literature on the subject of the study	12	16	13,6	S	13,6		20
The choice of direction of research	5	8	6,2	A,S	3,1		5
Drawing up a research plan	2	4	2,8	A,S	1,4		2
Design the layout of digital auscultometer	20	25	22	A,S	11		33
Creating a program in a PC for data processing and testing the device	25	30	27	A,S	13,5		20
The study using the developed digital of auscultometer	11	15	12,6	A,S	6,3		9
Analysis and processing of the results obtained	7	12	9	S	9		7
Making an explanatory note	6	11	8	S	8		12
Preparing for defense	5	10	7	S	7		10
TOTAL:			108,2		A 35,3	S 72,9	118

Based on the presented project plan, a schedule for conducting SR on the master's thesis was developed (table 11).

Table 11. Schedule of SR on the topic «Development of a digital ascultometer for the diagnosis of heart murmurs and lungs»

Work code	Type of work	Executors	Cal. days, T_c	The duration of execution of works														
				January				February		March			April			May		June
				1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1
1	Getting a task and theoretical review of the literature on the subject of the study	S	20																
2	The choice of direction of research	A,S	5																
3	Drawing up a research plan	A,S	2																
4	Design the layout of digital auscultometer	A,S	33																
5	Creating a program in a PC for data processing and testing the device	A,S	20																
6	The study using the developed digital of auscultometer	A,S	9																
7	Analysis and processing of the results obtained	S	7																
8	Making an explanatory note	S	12																
9	Preparing for defense	S	10																
Total			**118**																

Scientific adviser	
Undergraduate	

4.4. Research Budget

The calculation of material costs includes the cost of all materials used in the development of the project:

- raw materials purchased from outside;
- purchased materials used in the process of creating scientific and technical products;
- purchased components and semi-finished products that are subject to further installation or additional processing;
- raw materials and supplies, purchased components and semi-finished products used as research objects and for the operation, maintenance and repair of products.

4.4.1. Raw materials, supplies, purchased products and semi-finished products

In this article are included the cost of purchasing all types of materials, components and semi-finished products necessary for the execution of works on the subject. The quantity of required material values is determined by the consumption norms.

The cost of material costs is calculated based on current price lists or contractual prices. The cost of material costs includes transport and procurement costs (3-5 % of the price). This article also includes the cost of documentation (office supplies, replication of materials). The results for this article are entered in table 12.

Table 12. Raw materials, materials, components and purchased semi-finished products

Title	Brand, size	Number	Price per unit, RUB	Price, RUB
Microcontrollerr	ATmega16A-PU	1	120	120
Operational amplifier	LM082	2	7,7	15,4
Resister	chip 0805	9	0,17	1,53
Sq. resonator	HC-49S 16,000 MHz	1	10	10
Ceramic condenser	-	11	5	55
Transformer	TPG-2	1	127,12	127,12
Microchip	FT232RL SSOP28	1	180	180
Microcircuit	MAX232EPE, RS232	1	59	59
Diode bridge	RS206	2	10	20
Stabilitron	L7905CV	1	15	15
Stabilitron	L7805CV	1	15	15
Electrolytic aluminum capacitor	33 microfarad	2	2	4
	47 microfarad	1	3	3
	1000 microfarad	2	9	18
The total cost of materials				698,05
Transport and procurement expenses (3 - 5%)				27,92
Total for the item $C_м$				**725,97**

The following assumptions were made when calculating electricity costs for PC operation: taking into account the project's calendar schedule, it was assumed that 117 days were spent on work. The average power of a computer is about 0.3 kW / hour. The cost of electricity in Tomsk is 5.8 rubles per 1 kW / hour. The duration of working with a medium-power computer is 5 hours / day. Therefore, the power consumption of the computer during operation is:

$$0{,}3 * 5 * 5{,}8 * 117 = 1017{,}9 \text{ RUB.} \qquad (4.12)$$

4.4.2. Basic wage

Wages include the basic salary of employees directly engaged in the implementation of STI (including bonuses, surcharges) and additional wages, and are calculated using the formula:

$$S_s = S_{basic} + S_{add} \qquad (4.13)$$

Where, Z_{basic}– the basic salary; Z_{add}-additional salary (12-20 % of the Z_{basic}).

The basic salary S_{basic} of the head (laboratory assistant, engineer) from the enterprise (if there is a head from the enterprise) is calculated by the formula 4.14:

$$S_{basic} = S_{day} \cdot \text{T}_{work} \qquad (4.14)$$

Where, S_{basic} – the main salary of one employee; T_{work}– the duration of work performed by a scientific and technical employee, working days, S_{day}– average daily salary of an employee, RUB.

The average daily salary is calculated using the formula:

$$S_{day} = \frac{S_m \cdot \text{M}}{F_a} \qquad (4.15)$$

For a six-day work week (the Adviser's work week):

$$S_{day} = \frac{73049{,}6*10{,}4}{251} = 3026{,}8 \qquad (4.16)$$

For a six-day work week (student's work week):

$$S_{day} = \frac{37211{,}2*10{,}4}{247} = 1566{,}8 \qquad (4.17)$$

Where, $S_{м}$– the monthly official salary of the employee, RUB; F_a-the valid annual fund; M – the number of months of work without leave during the year.

On leave of 48 working days: $M = 10{,}4$ months, 6-day working week.

To calculate the basic salary, it is necessary to create a balance of working hours, shown in table 13.

Table 13. The balance of work

Indicators of working time	Adviser	Undergraduate
Calendar number of days	365	365
Number of non-working days - weekends - public holiday	52 14	104 14
Loss of working time: - vacation - absenteeism due to illness	48	-
Valid annual working time fund	251	247

Monthly official salary of an employee (formula 4.18):

$$S_M = S_b \cdot (1 + c_{bonus} + c_{sur.}) \cdot c_{reg} \qquad (4.18)$$

Where, S_b – base salary, RUB; c_{bonus}-bonus coefficient, equal to 0.3; $c_{sur.}$ - coefficient of surcharges and allowances is 0.3; c_{reg} - regional coefficient, equal to 1.3.

Table 14 shows the calculation of wages.

Table 14. Calculation of basic salary

Executors	S_b, RUB	c_b	c_s	c_r	S_M, RUB	S_{day}, RUB.	T_W, work days	S_{basic}, RUB
Adviser	35120	0,3	0,3	1,3	73049,6	3026,8	35,3	106846,1
Undergraduate	17890	0,3	0,3	1,3	37211,2	1566,8	72,9	114219,7
Total:								**221065,8**

4.4.3. Additional salary

Additional wages are calculated based on 10-15% of the basic salary of employees directly involved in the performance of work (formula 4.19):

$$S_{add} = c_{add} \cdot S_{basic} \qquad (4.19)$$

Where, S_{add}– additional salary, RUB; c_{add}-coefficient of additional salary, which is 15 %; S_{basic}– basic salary, RUB.

Table 15 shows the results of calculating the basic and additional wages.

Table 15. Table of basic and additional wages.

Salary	**Adviser**	**Undergraduate**
Basic salary	106846,1	114219,7
Additional salary	16026,9	17132,9
Total S_{add} :	**33159,8**	

4.4.4. Deductions on social needs

Deductions to extra-budgetary funds are a mandatory factor, according to the legislation of the Russian Federation, to the bodies of state social insurance (SSI), pension fund (PF) and medical insurance (FCMIF) from the cost of employee compensation.

To calculate contributions to non-budgetary funds, use the formula 4.20:

$$S_{extra-bud} = c_{extra-bud}(S_{basic} + S_{add}) \qquad (4.20)$$

Where, $c_{extra-bud}$ - is the coefficient of deductions for payment to extra-budgetary funds, equal to 27,1%.

Table 16. Contributions to extra-budgetary funds

Executor	S_{basic}, RUB	S_{add}, RUB
Scientific adviser	106846,1	16026,9
Undergraduate	114219,7	17132,9
Coefficient of deductions to extra-budgetary funds	27,1%	
Scientific adviser	33298,3	
Undergraduate	35596,6	
Total $S_{extra-bud}$:	**68894,9**	

4.4.5. Overhead

Overhead costs are 80-100 % of the amount of the main and additional wages of employees directly involved in the implementation of the theme.

The calculation of overhead costs is based on the following formula 4.21:

$$S_{over} = c_{over} \cdot (S_{basic} + S_{add}) \quad (4.21)$$

Where, c_{over} - is the overhead factor, which is 30 %.

Table 17. Overhead costs

Executor	S_{basic}, RUB	S_{add}, RUB
Scientific adviser	106846,1	16026,9
Undergraduate	114219,7	17132,9
Overhead factor	30%	
Scientific adviser	36861,9	
Undergraduate	39405,8	
Total S_{over}:	**76267,7**	

Table 18. The grouping of expenses under articles

Articles							
Raw materials (less returnable waste), purchased products and semi-finished products, RUB	Special equipment for scientific (experimental) work, RUB.	Basic salary, RUB.	Additional salary, RUB.	Deductions on social needs, RUB.	Other direct expenses, RUB.	Overhead, RUB.	Total planned cost, RUB.
725,9	-	221065,8	33159,8	68894,9	1017,9	76267,7	401132

4.5. Determining the resource, financial, budgetary, social and economic effectiveness of the research

The effectiveness is determined based on the calculation of an integral indicator of the effectiveness of scientific research. Its finding is associated with the determination of two weighted averages: financial efficiency and resource efficiency.

4.5.1. Integral financial indicator

This indicator can be determined using the formula (4.22):

$$I_{fin\ ind}^{execi} = \frac{F_{fin\ ind}}{F_{max}} \quad (4.22)$$

Where, F_{ind} – the cost of the $\mathrm{i-th}$ version of the execution; F_{max} – the maximum cost of execution of the research project. Integral indicators for various versions are shown below:

- $I_{fin\ ind}^{exec1} = 0{,}979$;
- $I_{fin\ ind}^{exec2} = 1$;
- $I_{fin\ ind}^{exec3} = 0{,}519$.

The resulting value of the integral financial indicator of development reflects the corresponding numerical increase in the development cost budget in times (a value greater than one), or the corresponding numerical decrease in the cost of development in times (a value less than one, but greater than zero).

4.5.2. Integral indicator of resource efficiency

The integral indicator of resource efficiency of variants of the object of research can be determined by the formula 4.23:

$$I_{ri} = \sum a_i * b_i \quad (4.23)$$

Where, $a_i -$ is the weight coefficient of the $i - th$ variant of the development execution; $b_i -$ is the score of the $i - th$ variant of the development execution.

Table 19 provides a comparative assessment of the characteristics of project execution options.

Table 19. Comparative evaluation of characteristics

Criteria \ SOFTWARE	The weighting factor parameter	Current project	Analog 1	Analog 2
Helps increase user productivity	0,1	4	3	3
Ease of use (meets the requirements of consumers)	0,15	5	4	4
Noise immunity	0,15	5	3	3
Energy saving	0,2	5	3	2
Reliability	0,25	4	3	3
Materials consumption	0,15	5	4	3
TOTAL:	1	4,63	3,33	3,08

The characteristics have similar criteria, since the methods are implemented for a single device. Each of the presented methods is implemented for a specific task, but the General characteristics are the same.

Example of calculating an integral resource efficiency indicator:

$$I_{\substack{current\\project}} = 0{,}1 * 4 + 0{,}15 * 5 + 0{,}15 * 5 + 0{,}2 * 5 + 0{,}25 * 4 + 0{,}15 * 5 = 4{,}63;$$

$$I_{Analog1} = 0{,}1 * 3 + 0{,}15 * 4 + 0{,}15 * 3 + 0{,}2 * 3 + 0{,}25 * 3 + 0{,}15 * 4 = 3{,}33;$$

$$I_{Analog2} = 0{,}1 * 3 + 0{,}15 * 4 + 0{,}15 * 3 + 0{,}2 * 2 + 0{,}25 * 3 + 0{,}15 * 3 = 3{,}08.$$

The integral indicator of development efficiency I^{r}_{finr} and analog I^{a}_{finr} is determined based on the integral indicator of resource efficiency and the integral financial indicator by the formula:

$$I^{r}_{finr} = \frac{I^{r}_{i(c.p.)}}{I^{r(exec)}_{fin.ind}},\ I^{a}_{finr} = \frac{I^{a}_{i}}{I^{a}_{fin.ind}} \quad \dots \qquad (4.24)$$

The comparative effectiveness of the project is determined by the formula 4.25:

$$E_{comp} = \frac{I^{r}_{fin\,r}}{I^{a}_{fin\,r}} \qquad (4.25)$$

Where, $E_{comp} -$ is the comparative effectiveness of the project.

Table 20 shows the comparative effectiveness of development.

Table 20. Comparative effectiveness

№	Indicators	Current project	Analog 1	Analog 2
1	Integral financial indicator	0,979	1	0,519
2	Integral indicator of resource efficiency	4,63	3,33	3,08
3	The integral indicator of efficiency	4,73	3,33	5,93
4	Comparative effectiveness of variants	1	1,42	0,8

Despite the fact that the first version was not the most effective, it is necessary to take into account that the equipment used for this development is not only used in this project.

Conclusions to the section

In this section, we discussed such issues as evaluating the commercial potential of research, planning and budgeting research, as well as determining the resource and economic efficiency of research.

Potential consumers of the research results were identified: a scientific laboratory, an industrial company, and an individual. Competitive technical solutions are analyzed. Scientific research consists of 8 works that are performed by two performers-a research supervisor and a student. The labor intensity of the work was determined, which was 117 days. The schedule of scientific research has been developed, as well as the budget for scientific and technical research has been calculated.

An integral financial indicator, an integral resource efficiency indicator, and the comparative effectiveness of the project are determined. Despite the fact that this scientific research was not the most effective, it is necessary to take into account that the equipment used for this development is not only used in this project.

CHAPTER 5. SOCIAL RESPONSIBILITY

The paper investigates the possibility of using a digital auscultometer for the diagnosis of noise and lungs. This trend raises the auscultative method to a higher level of development both by improving the quality of the modern diagnostic process, and by obtaining a wider range of diagnostic information. However, further processing of the signals received by the device will be handled at the enterprise by qualified personnel. The research was conducted at Tomsk Polytechnic University, in a specially equipped laboratory. Processing of the received information from the device and its visualization was performed on a computer consisting of a system unit and a monitor, so the work performed is reduced to interaction with a personal computer.

5.1. Legal and organizational items in providing safety

Nowadays one of the main way to radical improvement of all prophylactic work referred to reduce Total Incidents Rate and occupational morbidity is the widespread implementation of an integrated Occupational Safety and Health management system. That means combining isolated activities into a single system of targeted actions at all levels and stages of the production process.

Occupational safety is a system of legislative, socio-economic, organizational, technological, hygienic and therapeutic and prophylactic measures and tools that ensure the safety, preservation of health and human performance in the work process [29].

According to the Labor Code of the Russian Federation, every employee has the right:

- to have a workplace that meets Occupational safety requirements;
- to have a compulsory social insurance against accidents at manufacturing and occupational diseases;
- to receive reliable information from the employer, relevant government bodies and public organizations on conditions and Occupational safety at the

workplace, about the existing risk of damage to health, as well as measures to protect against harmful and (or) hazardous factors;

- to refuse carrying out work in case of danger to his life and health due to violation of Occupational safety requirements;
- be provided with personal and collective protective equipment in compliance with Occupational safety requirements at the expense of the employer;
- for training in safe work methods and techniques at the expense of the employer;
- for personal participation or participation through their representatives in consideration of issues related to ensuring safe working conditions in his workplace, and in the investigation of the accident with him at work or occupational disease;
- for extraordinary medical examination in accordance with medical recommendations with preservation of his place of work (position) and secondary earnings during the passage of the specified medical examination;
- for warranties and compensation established in accordance with this Code, collective agreement, agreement, local regulatory an act, an employment contract, if he is engaged in work with harmful and (or) hazardous working conditions.

The labor code of the Russian Federation states that normal working hours may not exceed 40 hours per week, the employer must keep track of the time worked by each employee.

Rules for labor protection and safety measures are introduced in order to prevent accidents, ensure safe working conditions for workers and are mandatory for workers, managers, engineers and technicians.

5.2. Basic ergonomic requirements for the correct location and arrangement of researcher's workplace

The workplace when working with a PC should be at least 6 square meters. The legroom should correspond to the following parameters: the legroom height is at least 600 mm, the seat distance to the lower edge of the working surface is at least 150 mm, and the seat height is 420 mm. It is worth noting that the height of the table should depend on the growth of the operator.

The following requirements are also provided for the organization of the workplace of the PC user: The design of the working chair should ensure the maintenance of a rational working posture while working on the PC and allow the posture to be changed in order to reduce the static tension of the neck and shoulder muscles and back to prevent the development of fatigue.

The type of working chair should be selected taking into account the growth of the user, the nature and duration of work with the PC. The working chair should be lifting and swivel, adjustable in height and angle of inclination of the seat and back, as well as the distance of the back from the front edge of the seat, while the adjustment of each parameter should be independent, easy to carry out and have a secure fit.

5.3. Occupational safety

A dangerous factor or industrial hazard is a factor whose impact under certain conditions leads to trauma or other sudden, severe deterioration of health of the worker [29].

A harmful factor or industrial health hazard is a factor, the effect of which on a worker under certain conditions leads to a disease or a decrease in working capacity.

5.3.1. Analysis of harmful and dangerous factors that can arise at workplace during investigation

The working conditions in the workplace are characterized by the presence of hazardous and harmful factors, which are classified by groups of elements: physical, chemical, biological, psychophysiological. The main elements of the production process that form dangerous and harmful factors are presented in Table 21.

Table 21. Possible hazardous and harmful factors

Factors (GOST 12.0.003-2015)	Work stages			Legal documents
	Development	Manufacture	Exploitation	
1. Deviation of microclimate indicators		+	+	Sanitary rules 2.2.2 / 2.4.1340–03. Sanitary and epidemiological rules and regulations "Hygienic requirements for personal electronic computers and work organization." Sanitary rules 2.2.1 / 2.1.1.1278–03. Hygienic requirements for natural, artificial and combined lighting of residential and public buildings. Sanitary rules 2.2.4 / 2.1.8.562–96. Noise at workplaces, in premises of residential, public buildings and in the construction area. Sanitary rules 2.2.4.548–96. Hygienic requirements for the microclimate of industrial premises.
2. Excessive noise		+	+	
3.Insufficient illumination of the working area	+	+	+	
4. Abnormally high voltage value in the circuit, the closure which may occur through the human body	+	+		Sanitary rules GOST 12.1.038-82 SSBT. Electrical safety. Maximum permissible levels of touch voltages and currents.

The following factors effect on person working on a computer:

- physical:
    - temperature and humidity;
    - noise;
    - static electricity;
    - electromagnetic field of low purity;
    - illumination;
    - presence of radiation;
- psychophysiological:
    - psychophysiological dangerous and harmful factors are divided into:
        - physical overload (static, dynamic)
        - mental stress (mental overstrain, monotony of work, emotional overload).

Deviation of microclimate indicators

The air of the working area (microclimate) is determined by the following parameters: temperature, relative humidity, air speed. The optimum and permissible values of the microclimate characteristics are established in accordance with [30] and are given in Table 22.

Table 22. Optimal and acceptable microclimate parameters

Period of year	Temperature, ^{o}C	Relative humidity, %	Speed of air movement, m/s
Cold transition	23-25	40-60	0,1
Warm	23-25	40	0,1

Excessive noise

Noise and vibration worsen working conditions, have a harmful effect on the human body, namely, on the hearing organs and on the entire body through the Central nervous system. As a result, attention is weakened, memory deteriorates, reaction decreases, and the number of errors during operation increases. Noise can be generated by operating equipment, air conditioning installations, daylight lighting devices, as well as from outside. When working on a PC, the noise level in the workplace should not exceed 50 dB.

Abnormally high voltage value in the circuit

Depending on the conditions in the room, the risk of electric shock increases or decreases. Do not work with a computer in conditions of high humidity (relative humidity of the air for a long time exceeds 75 %), high temperature (more than 35 °C), the presence of conductive dust, conductive floors and the possibility of simultaneous contact with metal elements connected to the ground and the metal body of electrical equipment. The operator works with electrical appliances: a computer (display, system unit, etc.) and peripherals.

The risk of electric shock exists in the following cases:

- when directly touching live parts during repair;
- when touching non-live parts that are energized (in case of violation of the insulation of live parts); when touching the floor, walls that are energized;
- when a short circuit occurs in high-voltage units: the power supply unit and the display scanner unit.

Electric current passing through the human body has thermal, chemical and biological effects.

Thermal (thermal) action is manifested in the form of burns of the skin, overheating of various organs, as well as resulting from overheating of blood vessels and nerve fibers.

Chemical (electrolytic) action leads to electrolysis of the blood and the other contained in the human body solutions that leads to change their physical and chemical compositions, and thus to the disruption of the normal functioning of the body

Activities to ensure electrical installations:

– disable voltage live parts on which or near which the work will be undertaken, and the adoption of measures to ensure the impossibility of applying a voltage to the working place;

- displaying posters indicating the place of work;
- ground buildings of all installations through the neutral wire;
- coating of metal surfaces of tools with reliable insulation;
- unavailability of current-carrying parts of equipment (enclosure of electro-reflecting elements, enclosure of current-carrying parts).

Insufficient illumination of the working area

Light sources can be both natural and artificial. The natural source of the light in the room is the sun, artificial light are lamps. With long work in low illumination conditions and in violation of other parameters of the illumination, visual perception decreases, myopia, eye disease develops, and headaches appear.

According to the standard, the illumination on the table surface in the area of the working document should be 300-500 lux. Lighting should not create glare on the surface of the monitor. Illumination of the monitor surface should not be more than 300 lux.

The brightness of the lamps of common light in the area with radiation angles from 50 to 90° should be no more than 200 cd/m, the protective angle of the lamps should be at least 40°. The safety factor for lamps of common light should be assumed to be 1.4. The ripple coefficient should not exceed 5%.

Dangerous and harmful industrial actors associated with electromagnetic fields that do not ionize human body tissues

Exposure to electromagnetic and electrostatic fields can lead to headaches and dysfunction of a number of organs. Electromagnetic radiation impairs the functioning of the brain vessels, which causes a weakening of memory, visual acuity, as well as diseases of the cardiovascular system, gastrointestinal tract, skin diseases.

The screen and system units produce electromagnetic radiation. The main part of it comes from the system unit and the video cable. According to the intensity of the electromagnetic field at a distance of 50 cm around the screen on the electrical component should be no more than:

– in the frequency range 5Hz-2kHz-25V/m;
– in the frequency range 2kHz-400kHz - 2.5 V/m.

The magnetic flux density must not exceed:

– in the frequency range 5Hz-2kHz-250ntl;

– in the frequency range 2kHz-400kHz-25ntl.

To protect against electromagnetic radiation, it is necessary to ensure:

– rational placement of radiating and irradiating objects, excluding or reducing the impact of radiation on personnel;

– limiting the location and time of employees in the electromagnetic field;

– distance protection;

– use of absorbing or reflecting screens;

– use of special protective glasses;

– medical and preventive measures.

In accordance with, this type of work in the laboratory belongs to group D, which means that it is worth reducing the time spent working at the computer, taking breaks with an 8-hour shift. Also use the monitors with a reduced level of radiation and protective screens.

5.3.2 Justification of measures to reduce the levels of exposure to hazardous and harmful factors on the researcher

Deviation of microclimate indicators

The measures for improving the air environment in the production room include: the correct organization of ventilation and air conditioning, heating of room. Ventilation can be realized naturally and mechanically. In the room, the following volumes of outside air must be delivered:

- at least 30 m^3 per hour per person for the volume of the room up to 20 m^3 per person;

- natural ventilation is allowed for the volume of the room more than 40 m^3 per person and if there is no emission of harmful substances.

The heating system must provide sufficient, constant and uniform heating of the air. Water heating should be used in rooms with increased requirements for clean air.

The parameters of the microclimate in the laboratory regulated by the central heating system, have the following values: humidity 40%, air speed 0.1 m / s, summer temperature 20-25 ° C, in winter 13-15 ° C. Natural ventilation is provided in the laboratory. Air enters and leaves through the cracks, windows, doors. The main disadvantage of such ventilation is that the fresh air enters the room without preliminary cleaning and heating.

Excessive noise

In research audiences, there are various kinds of noises that are generated by both internal and external noise sources. The internal sources of noise are working equipment, personal computer, printer, ventilation system, as well as computer equipment of other engineers in the audience. If the maximum permissible conditions are exceeded, it is sufficient to use sound-absorbing materials in the room (sound-absorbing wall and ceiling cladding, window curtains). To reduce the noise penetrating outside the premises, install seals around the perimeter of the doors and windows.

Abnormally high voltage value in the circuit

Measures to ensure the electrical safety of electrical installations:

- disconnection of voltage from live parts, on which or near to which work will be carried out, and taking measures to ensure the impossibility of applying voltage to the workplace;
- posting of posters indicating the place of work;
- electrical grounding of the housings of all installations through a neutral wire;
- coating of metal surfaces of tools with reliable insulation;
- inaccessibility of current-carrying parts of equipment (the conclusion in the case of electroporating elements, the conclusion in the body of current-carrying parts) [31].

Insufficient illumination of the working area

Desktops should be placed in such a way that the monitors are oriented sideways to the light openings, so that natural light falls mainly on the left.

Also, as a means of protection to minimize the impact of the factor, local lighting should be installed due to insufficient lighting, window openings should be equipped with adjustable devices such as blinds, curtains, external visors, etc.

5.4 Ecological safety

The computer used in the work does not entail negative impacts on the environment, so the creation of a sanitary protection zone and the adoption of measures to protect the atmosphere, hydrosphere, and lithosphere are not necessary. Computer in its composition contains toxic substances of e-waste such as brominated flame retardants, and polyvinyl chloride, mercury, are in the process of operation do not cause negative effects, however, over time, it is necessary to dispose of the personal computer as solid waste. At the end of the PC's service life, it can be classified as a waste of the electronics industry. During recycling, computers are disassembled into the following components: power supplies, processors, electronic boards, and cables. Disposal of electronic computers and other office equipment includes work on: loading, transportation, unloading, dismantling and extraction of various materials from written technical means, as well as delivery of materials to specialized organizations for further processing. The main materials that are extracted from technical means are: ferrous metal (aluminum, copper), plastic, boards containing precious metals, glass. Processing of such waste is carried out according to [30].

5.5 Safety in emergency

5.5.1 Analysis of probable emergencies that may occur at the workplace during research

According to, depending on the characteristics of substances used in production and their quantity, the fire and explosion hazard of the premises are divided into categories A, B, C, D, D. Since the room is classified as a category B by the degree of fire and explosion hazard, i.e. to rooms with solid combustion substances, it is necessary to provide a number of preventive measures.

Possible causes of fire:

– fault of current-carrying parts of installations;
– working with open electrical equipment;
– short circuits in the power supply;
– failure to comply with fire safety regulations;
– presence of flammable components: documents, doors, tables, cable insulation, etc.

5.5.2 Substantiation of measures for the prevention of emergencies and the development of procedures in case of emergencies

Measures for fire prevention are divided into: organizational, technical, operational and routine.

Organizational measures include proper operation of equipment, proper maintenance of buildings and territories, fire-prevention instruction of workers and employees, training of production personnel in fire safety rules, publication of instructions, posters, and an evacuation plan.

Technical measures include: compliance with fire safety rules and regulations in the design of buildings, when installing electrical wiring and equipment, heating, ventilation, lighting, and proper placement of equipment.

To the performance measures include establishment of rules of work organization and compliance with fire prevention measures. To prevent fire from short circuits, overloads, etc., the following fire safety rules must be observed:

– elimination of the formation of a flammable environment (equipment sealing, air monitoring, working and emergency ventilation);

– use of non-combustible or hard-to-burn materials in the construction and decoration of buildings;

– correct operation of the equipment (correct connection of the equipment to the power supply network, control of heating of the equipment);

– proper maintenance of buildings and territories (excluding the formation of a source of ignition-preventing spontaneous combustion of substances, limiting fire operations);

– training of production personnel in fire safety rules;

– publication of instructions, posters, and an evacuation plan;

– compliance with fire safety rules and regulations in the design of buildings, when installing electrical wiring and equipment, heating, ventilation, lighting;

– correct placement of equipment;

– timely preventive inspection, repair and testing of equipment [32].

If an emergency occurs, you must:

1. Inform the management (on duty).

2. Call the appropriate emergency service or EMERCOM-tel. 112.

Take measures to eliminate the accident in accordance with the instructions.

Conclusions

In this Chapter, we discussed sanitary and technical standards, safety practices, work in emergency situations, as well as organizational issues to ensure the safety of the work area. Possible sources of harmful and dangerous factors were identified, and a set of measures was proposed to minimize the negative impact of factors that occur when working with a computer or an experimental installation. Thanks to these measures it is possible to raise labor productivity and improve working conditions in the laboratory.

Conclusions

Based on the analysis of the results obtained in the study, the following conclusions are drawn:

1. Based on the received audio signal graphs, can see that when using high- and low-frequency filters and amplify the TL082 signal, the noise became smaller and the tones are more clearly visible.
2. When processing data by a computer, an amplitude-frequency analysis method is used, which allows to determine the full spectral component of the signal, which allow to get complete information about the sound signals.
3. According to the results of the frequency spectrum of the heart sound, 2 peaks can be distinguish – in the region of 30 Hz and 65-70 Hz; these maximum amplitudes correspond to the vibrations generated at the first and second tones. Also, according to the obtained frequency spectra of sounds of the 2 lungs, they differ from each other – in the frequency components above 200 Hz are amplified, which is consistent with data from the relevant literature.
4. Based on all this, we can conclude that the study of characteristics showed the effectiveness of the device in the diagnosis of the heart and lungs. The device clearly identifies sounds of various origins.

The study of characteristics showed the effectiveness of the device in the diagnosis of the heart. The device clearly identifies sounds of various origins. Based on the results obtained, the developed program allows you to make diagnostics based on the type of frequency spectrum.

The advantages of the created auscultometer include:

- high sensitivity and resolution
- availability and low cost of components.

Thus, to date, the modernization and improvement of the auscultation method is one of the most important areas of medicine. This trend raises auscultative methods to a high level of development through improving the quality of modern diagnostic measures, as well as further expanding the range of diagnostic information. This ensures that a progressive new level in the development of the auscultation method provides more information about new implementations using a digital auscultometer, will be effective not only at the initial stage of the patient's research, but also at all stages.

References

1. 10 leading causes of death in the world / / who Newsletter 2016. - N 310 [Electronic resource]. URL: http://www.who.int/mediacentre/factsheets/fs310/ru/ (accessed: 07.02.2017).
2. Executive Summary: Heart Disease and Stroke Statistics-2016 Update / D. Mozaffarian, E. J. Benjamin, A. S. Go, D. K. Arnett, M. J. Blaha, M. Cushman, S. R. Das, S. de Ferranti, J. P. Despres et al. // Circulation. – 2016. – Vol. 4, N 133. – p. 447-454.
3. Allergic diseases in children. Doctor's guide//Under the editorship of M. ya. studenikina, I. I. Balabolkin-M.: "Medicine", 1998. - 352 p. 2. Zaitseva O. V.
4. Bronchial asthma in children//Russian medical journal, 2007, no. 7, p. 582587.
5. Krasnov L. A., Oleinik V. P. phonocardiography. Technical means of electronic and computer diagnostics in medicine, Kharkiv, 2013.
6. Oleynik V. P., Kulish S. N., Hardware research methods in biology and medicine, Kharkiv, 2004.
7. Adamov S. A. and Kovalevsky A. A. Percussion and auscultation a Short course for students and doctors. - Tomsk, 1938.
8. Krasnov, L. A. Phonocardiography. Technical means of electronic and computer diagnostics in medicine [Text]: textbook. manual / L. A. Krasnov, V. P. Oleinik. // Kh.: National aerospace. N. E. Zhukovsky uni-t " Kharkiv. aviation. inta».2013– 64 pages
9. Kukes V. G., Marinin V. F., reutsky I. A., Sivkov S. I., Medical methods of diagnostics, Moscow, 2006.
10. Fachinger P., Computerbasierte Analyse von Lungengeräuschen bei Patienten mit Pneumonie-Automatische Detektion des Bronchialatmens mit Hilfe der Fast-Fourier-Transformation, Marburg, 2003.
11. Karpov R. S., Dudko V. A., Klyashev S. M. Heart-lungs: pathogenesis, clinic, functional diagnostics and treatment of combined forms of ischemic heart disease and chronic obstructive pulmonary diseases, Tomsk, 2004.

12. Komar S. I., lung Auscultation and electronic acoustic analysis of respiratory noises, Chelyabinsk, 2008
13. Yuldashev K. Yu., Haidarov T. S., Kushakov V. I., Brief manual of electro-and phonocardiography, Tashkent, 1984.
14. Abbas K., Rasha B, Phonocardiography Signal Processing
15. Udaltsov B. B., Fundamentals of clinical phonocardiography, Saint Petersburg, 2000.
16. Reisse A, Objektivierung von Herzgeräuschen beim Rind mittels Phonokardiographie, München, 2008.
17. Auscultation of the heart. Heart murmurs: a textbook for students/ Yu. V. Oslopova, V. N. Oslopov, O. V. Bogoyavlenskaya-Kazan: 2015-100 p.
18. Acoustic components [electronic resource] / URL: http://www.fotorele.net/microfon.html. Date of application: 12.04.2014
19. ECM-4F - (P) [electronic resource] URL: http://tec.org.ru/board/ecm_9767/14-1-0-823. Date of application: 12.04.2014
20. Computerized Heart Sounds Analysis [electronic resource] / URL: http://www.sciencedirect.com/science/article/pii/S0010482507001771. Date of access: 10.04.2014.
21. Horowitz P., hill U., Art of circuit engineering, Moscow, 1993.
22. Nogin V. N., Analog electronic devices, Moscow, 1992.
23. Jones M., electronics-practical course, Moscow, 2006.
24. Baranov V. N., Application of AVR microcontrollers: schemes, algorithms, programs, Moscow, 2004.
25. N. A. ZADOROZHNY, A. S. Chuev. Laboratory work e-202. RC-filters, differentiating and integrating circuits: a Brief methodological guide. - Moscow: Bauman Moscow state technical University, 2017. - 22 p.
26. Arkhangelsk A. Ya., Programming in C++ Builder 6, Moscow, 2003.
27. Podbelsky V. V., Fomin S. S., Programming in C, Moscow, 2004.
28. Gavrikova N. A., Tukhvatulina L. R., Vidyaev I. G., Financial management, resource efficiency and resource saving, Tomsk, 2014.

29. Federal law" on the basics of labor protection " dated 17.07.1999, No. 181-FZ.
30. SanPiN 2.2.2/2.4.1340-03. Sanitary and epidemiological rules and regulations "Hygienic requirements for personal computers and work organization".
31. GOST 12.1.038-82 OCCUPATIONAL SAFETY STANDARDS. Electrosecurity.
32. Fire and explosion safety of industrial facilities. GOST R12. 1. 004-85 SSBT Fire safety.