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 bioimpendance spectrometer for measuring damage to breast tissue after radiation therapy

UDC 621.386.85:615.849:616-018

Student

Group	Full name	Signature	Date
0AM8M	Bissenbayeva Berikkul		

Scientific supervisor

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

Adviser

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Medical physicist Research Institute of Oncology, TNIMC 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”

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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	Bissenbayeva Berikkul

Topic of research work:

Development of a bioimpendance spectrometer for measuring damage to breast tissue after radiation therapy	
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:	Development of a bio-impedance spectrometer for monitoring the state of tissues after radiation therapy sessions for patients with breast cancer.

List of the issues to be investigated, designed and developed	Performing a literature review of the research topic; Development of a bioimpedance spectrometer Perform diagnostics and study of its characteristics Measure phase angle in a patient with breast cancer.

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

Section	Advisor
Financial Management, Resource Efficiency and Resource Saving	Menshikova E.V.
Social responsibility	Verigin D.A.

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 status	Signature	Date
Associate Professor	Cherepennikov Yu.M.	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	Bissenbayeva Berikkul		

TOMSK POLYTECHNIC UNIVERSITY — ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

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School School of Nuclear Science & Engineering
Field of training (specialty) 14.04.02 «Nuclear Physics and Technology»
Level of education Master Degree Program
Division Division for Nuclear-Fuel Cycle
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)
27.01.2020	1. Preparation of technical specifications and selection of research areas	10
24.02.2020	2. Development of a common research methodology	10
23.03.2020	3. Selection and study of materials on the topic	10
13.04.2020	4. Obtaining the necessary experimental data and verification of the results	20
27.04.2020	5. Processing the received data	20
18.05.2020	6. Registration of the work performed	15
29.05.2020	7. Preparation for the defense of the thesis	15

COMPILED BY:
Scientific supervisor

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

Adviser (if any)

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	Bissenbayeva Berikkul

School	School of Nuclear Science & Engineering	**Division**	Division for Nuclear-Fuel Cycle
Degree	Master Degree Program	**Field of training/programme**	14.04.02 Nuclear physics and technology / Nuclear medicine

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*	- Material costs 1761,4 rubles. - The main salary of the theme performers is 65428 rubles. - Costs of special equipment for scientific (experimental) work 2924.5 rubles. Overhead 16 1,1 rubles
2. *Expenditure rates and expenditure standards for resources*	Tariff for industrial electricity 5.8 per 1 kW • h - District coefficient of the city of Tomsk -1.3
3. *Current tax system, tax rates, charges rates, discounting rates and interest rates*	The amount of insurance premiums is 30%. Reduced rate - 27%.
The list of subjects to study, design and develop:	
1. *Assessment of commercial and innovative potential of STR*	Competitive Technical Scorecard
2. *Development of charter for scientific-research project*	- SWOT analysis; - Planning of research work; - Development of a schedule for conducting scientific research (Gantt chart).
3. *Scheduling of STR management process: structure and timeline, budget, risk management*	The budget of scientific and technical research: calculation of material costs; calculation of the primary and secondary; salary performers topics; overhead costs; cost budgeting
4. *Determination of resource, financial, economic efficiency*	…

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	

The task was issued by adviser:

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

The task was accepted by the student:

Group	Full name	Signature	Date
0AM8M	Bissenbayeva Berikkul		

TASK FOR SECTION
«SOCIAL RESPONSIBILITY»

For a student:

group	Full name
0AM8M	Bissenbayeva Berikkul

School	School of Nuclear Science & Engineering	**Division**	Division for Nuclear-Fuel Cycle
Degree	Master Degree Program	**Field of training/programme**	14.04.02 Nuclear Physics and Technology/Nuclear Medicine

Development of a bioimpendance spectrometer for measuring damage to breast tissue after radiation therapy	
Initial data for section «Social Responsibility»:	
1. Information about object of investigation (matter, material, device, algorithm, procedure, workplace) and area of its application	Investigation of effect of coolant injection parameters on mitigation of core melting accident by simulation on PC. Application area: safety of nuclear reactor
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.	– Labour code of Russian Federation #197 from 30/12/2001 GOST 12.2.032-78 SSBT – 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	– Enchanced electromagnetic radiation level – Insufficient illumination of workplace – Excessive noise – Deviation of microclimate indicators – Electric shock – Ionizing radiation
3. Ecological safety:	– Indicate impact of high frequency radio waves generators on hydrosphere, atmosphere and lithosphere
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 consultant:

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

The task was accepted by the student:

Group	Full name	Signature	date
0AM8M	Bissenbayeva Berikkul		

Abstract

Master's Graduation work consists of 80 pages, 14 figures, 22 table, 25 sources.

Keywords: breast cancer, bioimpedance spectrometry, radiation therapy, dispersion.

The object of research is a bio-impedance spectrometer for measuring physiological tissue changes after radiation therapy.

Aim of work is development of a bio-impedance spectrometer to determine the physiological status of living tissue after a cancer radiation therapy session with a diagnosis of breast cancer.

In the process of research were carried a device for bio-impedance spectrometry was developed.

As a result of the study the tests showed that the device allows you to measure bioimpedance in the frequency range from 10 Hz to 100 kHz. The efficacy of using the device in the diagnosis of tissues after radiation therapy sessions was also shown.

Cost effectiveness/significance the device is simple in construction and economical for production.

Application area: nuclear medicine, breast cancer.

Planned in the future using bio-impedance spectrometry can minimize side effects.

The master's thesis was written in a Microsoft Word 2016 text editor using Microsoft Excel 2016 packages.

Contents

Introduction

Among oncological diseases, breast cancer occupies the front ranks of proliferation worldwide. There are many factors and phenomena affecting the occurrence of breast cancer. Factors influencing this is the early menarche and late birth. Breast cancer is also characterized by pronounced genetic susceptibility. Earlier detection and treatment progress began to reduce mortality in several countries. Thanks to the use of DNA expression profiles, it is possible to determine the diagnosis at an early stage. There are a number of diagnostic methods for recognizing cancer: mammography, ultrasound, MRI, etc. Through the diagnosis, it is possible to determine the stages and location of the tumor to prescribe the desired proder treatment. To detect cancer at an early stage, medicine uses X-ray and ultrasound examinations everywhere. There are 4 main methods for treating breast cancer: surgical, hormone therapy, chemotherapy and radiation therapy. In the treatment of breast cancer, the method of radiation therapy is mainly relevant. After the use of radiation therapy, it is very important to monitor the physiological changes in living tissues in the irradiated area.

To identify complications in the field of irradiation, it is necessary to develop an instrument that determines and gives the accuracy of the results, and using a bio-impedance spectrometer we can assess tissue damage during irradiation, may be important for evaluating the initial treatment in cases of tumor recurrence.

The aim of the work is the development of a bio-impedance spectrometer to determine the physiological status of living tissue after a session of radiation therapy for cancer with a diagnosis of breast cancer.

To achieve the integrity of the following tasks:

1. Performing a literature review of the research topic
2. Development of a bioimpedance spectrometer
3. Perform diagnostics and study of its characteristics
4. Measure phase angle in a patient with breast cancer

1. Literature review

1.1 Breast cancer

Cancer of the female breast occurs in different ways, differing in localization, degree of differentiation and severity. One of the most common is infiltrating ductal breast cancer. The prognosis for it is rather unfavorable.

The word "infiltrative" in the name of this disease means that the tumor is not delimited from the surrounding breast tissue, but grows in them, and at the same time destroys the cells.

Invasive ductal carcinoma of the breast is prone to rapid growth, as a result of which the prognosis of the disease is often poor.The mammary gland is a paired organ that is functionally related to the female reproductive system. By origin represents a modified skin sweat gland. The mammary glands are located on the front surface of the chest, between the III – VII ribs, bounded by the edge of the sternum and the anterior axillary line. Breast tissue can spread beyond its visible contours, forming “processes” - axillary, clavicular, sternal, posterolateral.

The structural basis, the "skeleton" of the mammary gland is created by the superficial fascia (connective tissue membrane). Splitting into two sheets, it forms a kind of bag (fascial case), in which the parenchyma (the body itself) of the gland is enclosed. From the sheets of the capsule into the depths of the gland, connective tissue septa diverge the gland into 15–20 lobules [2], from which large lobes form (fig.1).

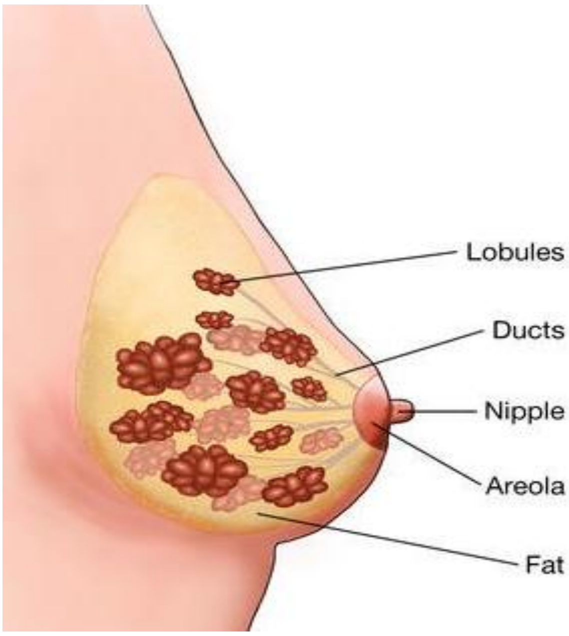

Figure 1 - the structure of breast cancer

Parenchyma segments sometimes lie separately from its bulk, and then they are called supplemental. It is additional lobules and processes that can serve as a source of benign and malignant neoplasms.[1]

The detection of the main triggering factor leading to the occurrence of breast cancer is multitude, each year the study gives new results and adds to the list of factors triggering cancer. While scientists are in search of the main mechanism for triggering the disease. The main defect in recognizing the tumor is the importance of studying the cell. As we know from the initial courses of biology, a cell is a structural and functional unit of living organisms, just like a living organism, it grows and multiplies. Under normal conditions, cells of organs and tissues interact in a certain way. However, with the growth of the tumor, such interconnections are violated, one of the signs of a disruption in the relationship is fencing from other cells. Apparently, this condition leads to the release of malignant cells from the control of factors that coordinate cell proliferation (reproduction), which under normal conditions constantly circulate through intercellular membranes [3].

Factors causing a change in cell function due to cancer can be chemical or physical.

The difference between oncogenic cells and normal is many.

main:

- chemicals appear in the cells giving independence from other cells;

- provide the benefits of survival by changing the cellular metabolism of carbohydrates, proteins, fats, increased absorption necessary for the growth of compounds from healthy tissues;

- accumulate water and some electrolytes;

- disturbed organization of cells;

- acquire structural complexes (antigens) that are absent in normal cells or lose existing ones (antigenic simplification) [4].

According to the mechanism of occurrence, breast cancer is divided into 3 groups:

- accidental (sporadic cancer about 65% of all tumors), the leading role in the etiology of which is given to prolonged or intensive exposure to estrogens.

- cancer that is betrayed by the family type - in the presence of breast cancer in mothers, sisters and daughters, the risk of the disease increases manifold[5].

- inherited cancer, which is transmitted both from the maternal and paternal sides. It is based on mutations of the BRCA 1/2, p53, pTEN, CHEK 2 genes. Genetically predisposed cancer is approximately 9%.

The most important breast cancer risk factors:

- Early puberty in adolescent girls and late onset of menopause in women.

- late (after 30 years) first birth and nulliparous women.

- age over 50 years.

- a typical hyperplasia of breast tissue during biopsy.

- the presence in the family history of breast cancer (especially in direct relatives in premenopause).

- mutations of the BRCA-1 and BRCA-2 genes.

- a history of breast cancer.

Based on the research that has been done many times, they give the result that the main cause of cancer is the warming of foods that contain animal fat. Also, women who have excess abnormalities of adipose tissue are at risk. Conducting hormone replacement therapy and oral contraceptives slightly increase the risk of developing breast cancer, which should not interfere with the appointment of this treatment, if there are objective indications for it[6]. These factors contribute to the occurrence, but it is ambiguous, it is a probability in the detection of cancer after diagnosis. Even in the absence of such factors, it does not guarantee the occurrence of breast cancer.

There are several clinical forms of breast cancer: nodular, diffuse (edematous-infiltrative, erysipelas, mastitis), Paget's breast cancer.

The most common types are nodular breast cancer in 80% of cases. One manifestation of the appearance in the mammary gland of a nodular form of deformed cells in breast tissue. The upper-outer quadrant (up to 50%) is most often affected. Unfortunately, it should be noted that in approximately 80% of cases, women detect changes in the mammary gland themselves.

Young women often develop a diffuse form of cancer. This form is malignant and rapidly progressive. due to quality, tumor accumulation and densification of the entire breast tissue is at risk; increase in size due to tumor infiltration; increase in its size; hyperemia of the skin of the mammary gland and local hyperthermia (with mastitis-like and erysipelatous forms, a general temperature reaction is possible); a pronounced symptom of "lemon peel" over the entire surface of the mammary gland; a sharp thickening of the nipple and areola folds; retraction and firm fixation of the nipple; in the vast majority of cases, there are affected axillary lymph nodes. In some cases, the differential diagnosis of diffuse forms of breast cancer is very difficult, especially with mastitis and erysipelas of the skin. Primary diffuse forms of cancer are distinguished when the tumor node in the gland is not determined, and the secondary ones with the presence of a tumor, often larger, in which edema and infiltration of the gland and skin tissue are caused by a block of the abducting lymphatic system due to massive damage to regional lymphatic collectors. [7]

1.2 Breast Cancer Treatments

Breast cancer treatment is divided into: surgery, radiation therapy, chemotherapy, and comprehensive treatment combination of all types of treatment. Among these types of treatment, the surgical treatment predominates[16].

When drawing up a treatment plan, attention is drawn to such factors as the patient's age, stage of breast cancer, tumor morphological structure, and general condition of the patient.

the goal is to obtain effective results:

- the goal of radical treatment in the initial period is to achieve the maximum positive result[17].
- The goal of the pallitic method of treatment is to reduce the symptom of symptoms.

Treatment can be divided into two components: local radiation - surgical treatment and radiation therapy and system - chemotherapy, hormone therapy, targeted therapy.

Surgery. The operations of choice in breast cancer are radical mastectomy in various modifications, radical resection (sectoral resection with axillary lymph node dissection), lumpectomy, tumor resection[18].

Organ-preserving operations, widespread in recent years, are not indicated for large tumor sizes in the small mammary gland. Complications of surgical treatment for breast cancer are: secondary lymphostasis of the upper extremity associated with the removal of the main pathways of lymphatic drainage during axillary lymphatic dissection, skin sensitivity disorders associated with the intersection of the intercostal brachial nerves, tissue deficiency of the anterior chest wall, increased sweating, scarring of the skin.

Cosmetic defects after radical surgeries, leading to significant psycho-emotional trauma in the operated women, are now eliminated by the increasingly widespread implementation of simultaneous or delayed reconstructive plastic surgeries. A tissue defect is replaced either by the body's own tissues (autoplasty) or another method of plastic surgery is alloplasty - the installation of silicone endoprostheses or expanders.

Radiation therapy for breast cancer is combined with surgery, chemotherapy and allows the suppression of the growth of metastases in the lymph nodes and blood and lymph vessels. As an independent method of preoperative therapy, radiation therapy is currently practically not used. After the operation, complications such as post-radiation erythema and edema, p fibrosis, lymphostasis, radiation pulmonitis and radiation myocarditis are rare in the irradiated areas.

Chemotherapy is used to prevent and treat metastasis, and also helps prevent the first manifestation. With breast cancer, the use of chemicals gives an oscillating result. The effectiveness of the drugs is minimal starting from 20 to 75%. A combination of chemicals is used to enhance the antitumor effect[10].

Taxanes and anthracyclines are distinguished from chemical preparations; they have the highest antitumor activity in breast cancer. when prescribing chemotherapy, the choice of drug is based on its spectrum of action, the mode and type of drug administration, selection of the optimal dose, consideration of factors requiring dose adjustment in order to avoid severe complications of chemotherapy.

The toxicity of chemotherapy is explained by the destructive effect of drugs not only on tumor cells, but also[11] on the general condition of the patient.Intervals of 3-4 weeks between the introduction of chemotherapy provides complete regeneration of damaged normal tissues [3]

Depending on the time of chemotherapy, it is divided into neoadjuvant, which is carried out before the operation in order to reduce the tumor mass, transfer the tumor to an operable state for possible organ-preserving surgery, and adjuvant, which is carried out after the operation in order to suppress possible micrometastases of cancer in the organs and tissues of the body.

1.2.1 Surgical treatment of breast cancer

The surgical treatment for breast cancer is the main treatment of all. The method of radiation and chemotherapy is combined with the surgical method [12].

In patients with an initial stage with a tumor size of up to 2.5 cm, it can be treated with organ-preserving treatment, the results of which do not differ from those with mastectomy. Organ-preserving operations include a lumpectomy, wide tumor removal in healthy tissues with a satisfactory cosmetic result. With the removal of large volumes, an aesthetic effect can be achieved only with simultaneous reconstruction of the gland. Mandatory stage - axillary lymphadenectomy or biopsy of the sentinel lymph node[14].

A mastectomy can be performed with simultaneous reconstruction of the mammary gland with its own tissues without or in combination with an endoprosthesis.

Contraindications to surgical treatment

The prevalence of the tumor process:

- widespread swelling of the skin of the mammary gland with a transition to the chest wall[15]
- edema of the upper limb as a result of multiple metastases in the lymph nodes
- Extensive expression of the skin, germination by a tumor in the chest wall.

General contraindications:

- severe cardiovascular failure
- expressed metabolic disturbances
- compensation of diabetes mellitus, severe renal and hepatic insufficiency

Basic options for operations

1. Lumpectomy.
2. Radical sectoral resection
3. Quadrantectomy with lymphadenectomy.
4. Subtotal resection with lymphadenectomy.
5. Subcutaneous mastectomy with lymphadenectomy

Lumpectomy is understood to mean the removal of a palpable tumor within healthy tissues without extensive excision. Other types of operations involve the removal of at least 2, and often up to 4 cm, of healthy tissue along the edges of the tumor. Organ-preserving operations must be supplemented with radiation therapy.

The volume of tissue removed is determined by the size of the tumor, its histological characteristics and the results of intraoperative cytological examination, damaging the absence of a tumor at the edges of the resection.

Sectoral resection

The term itself defines that the volume of tissue removed corresponds to the breast tissue sector (usually a few lobes) with the tumor and the main ducts.

When a small tumor is located in the upper outer quadrant, tumors and axillary lymph nodes can be removed in a single block by extending the incision along the edge of the pectoralis major muscle. During these operations, for aesthetic reasons, it is necessary to synchronize at least 2/3 of the gland.

1.2.2 Radiation therapy for breast cancer

Modern devices for radiotherapy allow aiming to direct radiation to the corresponding area of the body, where a tumor is located. The most common are the so-called linear accelerators. This special apparatus creates the radiation flux, which has clear boundaries, pronounced penetration into the tissue and high energy, which can reduce the time of the procedure itself.

There is also a brachytherapy technique when the radiation source injected directly into the body, however this type of radiotherapy with breast cancer is rarely used.

The goal of radiotherapy is to destroy cancer cells and at the same time damage the healthy cells of the body as little as possible. Radiation therapy is carried out in very many oncological diseases. In breast cancer, radiotherapy is usually carried out after surgery in order to destroy cancer cells that may have remained after surgery. If also

If drug therapy is required, then radiation is prescribed four weeks after its completion. In some cases, both radiation and chemotherapy occur simultaneously.

Radiation therapy (X-ray therapy, telegammotherapy, electron therapy, neutron therapy, etc.) is the use of a special type of energy of electromagnetic radiation or beams of elementary nuclear particles that can kill tumor cells or inhibit their growth and division.

In the treatment of breast cancer, radiation therapy is always combined with surgical treatment, in which only part of the breast has been removed, or if cancer cells are found in nearby lymph nodes. The goal of postoperative radiation therapy is the destruction of microscopic small cancer colonies that remain in the area of the operation or in the nearby lymph nodes.

Neutron therapy is a type of radiation therapy carried out using neutron radiation. The method is based on the ability of neutrons to be captured by atomic nuclei with the subsequent transformation and emission of α-, β- and γ-quanta, which have a biological effect. In neutron therapy, remote, intracavitary, and interstitial irradiation are also used[9].

Remote radiation refers, for example, to the so-called neutron capture therapy. In this case, the therapeutic effect is manifested as a result of the capture of thermal or intermediate neutrons (energy below 200 keV) by the nuclei of stable isotopes previously accumulated in the tumor (for example, 10V), which undergo the decay under the influence of captured neutrons.

asks of preoperative telegammotherapy:

- To stop the flow of clonogenic cells into the bloodstream, the process of cell devitalization is used. 1-2 days before surgery, a course of irradiation is performed. in which, first of all, the area of axillary lymph nodes is irradiated by 5 g every other day, 25 g each. Or the second method is used to irradiate the impact on the zone at a time of 10-13g.

- Before surgical treatment of types of breast cancer T3-4, an irradiation course is performed with a total dose of 40Gy, a single dose of 2.5Gy. After exposure to skin, the reactions in the field of radiation subside after 2 -3 weeks. And then you can start the operation.

To reduce the risk of re-occurrence and metastasis of the tumor, postoperative chest irradiation is used. Swollen with a size of more than 5 cm and 4 more affected lymph nodes give a risk of recurrence of swelling by 25 percent.

the radiation dose during organ-preserving operations is: to the area of the remaining part of the mammary gland 50Gy, to the area of lymph nodes 40Gy. The course of exposure is assigned no later than 84 days after the determination.

With the integrated use of chemical preparations, hormonal preparations to reduce the metastasis of tumors after surgery, telegram therapy is much more likely to spread local relapses. and this affects the effectiveness of the treatmen

In special cases, when treatment poses a threat to the patient or when the patient refuses surgery, radiation therapy is carried out as the main treatment method. For the full course of treatment, high doses up to 90 Gy are required, which go beyond the tolerance of surrounding normal tissues, therefore treatment cannot be radical, but as statistics show for elderly patients, treatment gives a good effect

Complications of radiation therapy

After radiation therapy, the patient shows signs of complication, general and local complications. Signs of general deposition are a decrease in appetite, poor health, a decrease in blood counts, and weakness, and local signs include changes in the skin in the area of radiation like radiation dermatitis. All signs of general, local complications can be corrected during treatment and disappear after the end of a course of radiation therapy, including myocardial damage. For less damage to the myocardium, it is better to use new devices that change position during treatment

1.2.3 Chemotherapy for breast cancer

After determining the stage of breast cancer, if the tumor size is not more than two centimeters, then there is the possibility of treatment only with chemotherapy. Chemotherapy is an adjunctive treatment method; many patients are prescribed treatment with chemical drugs before and after surgery. Chemotherapy by type is divided into two: adjuvant and non-adjuvant, adjuvant is used after surgery and non-adjuvant before. In most patients after surgery, as well as with common tumors and before it, chemotherapy is necessary. An advantage is given to schemes using anthracyclines.

Modern methods of complex treatment allow achieving a positive result in 50-80% of patients with advanced breast cancer. Since the benefits of combination chemotherapy for breast cancer gives a good result. To improve the quality of the result, new chemical preparations are annually re-launched.

Adjuvant chemotherapy

Thanks to adjuvant therapy, the treatment of breast cancer is painless. The procedure increases the survival of patients and prolongs the period without disease. And it also matters, in case of relapse in the future, the tumor remained sensitive to cytostatics, and if in case of an increase in the relapse-free period it will be accompanied by a decrease in overall survival. The time of adjuvant therapy is prescribed for 14 aphids 28 days after surgery. Due to the fact that micrometastases consist of a heterogeneous mass of tumor cells, many of them remain inactive during chemotherapy, therefore chemotherapeutic drugs also damage healthy cells. If you reduce the intake of chemical preparations, the level of metastasis will increase. Chemotherapy is most common with an interval of 28 days, during which complete regeneration of damaged normal tissues of the body is ensured

Nonadjuvant chemotherapy

Before the surgical treatment, non-adjuvant chemotherapy is prescribed. Non-adjuvant chemotherapy is intended to reduce or eradicate micrometastases. Non-adjuvant chemotherapy is effective in reducing the size of the tumor, which is a plus before surgery. The use of cytotastatic agents during treatment is mandatory, because they are good at stopping metastases and their spread.

2. Impedance of biological tissues

2.1 Impedance - basic concepts

The impedance of an element at a specific frequency is defined as the ratio between voltage and current for that frequency. In this case, there are two relationships between current and voltage: the first is the relationship between the amplitudes and the second is the relationship between the phases of the current and voltage, that is, the delay between the current and voltage. AC signals are represented by complex numbers that have a module and a phase. This representation allows simultaneous calculations with the magnitude module and its phase.

Complex number: c = a+jb

$$\begin{cases} the\ real\ part\ c\text{: Re (c)} = \text{a} \\ imaginary\ part\text{: Im(c)} = \text{b} \end{cases} \quad (1)$$

$$\begin{cases} : IcI = \sqrt{Re\{c\}^2 + Im\{c\}^2} \\ Phase: \llcorner c = \arctan\left(\frac{Im\{c\}}{Re\{c\}}\right) \end{cases} \quad (2)$$

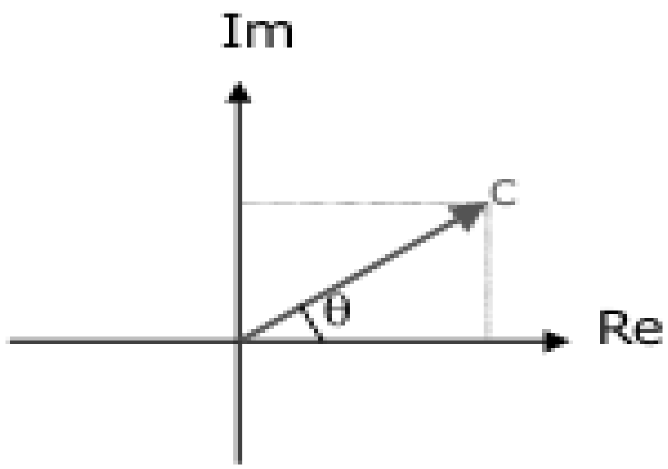

Figure 2 - Representation of numbers on the complex plane

For a given frequency, both voltage and current are represented by amplitude and phase. Therefore, the electrical impedance is equal to the ratio of the amplitudes and the phase difference[19].

$$Z = V/I \text{ this implies } |Z| = |V|/|I|, \angle Z = \angle V - \angle \quad (3)$$

The real part of the impedance is called resistance, and the imaginary part is called reactance. The real part of Re (Z) causes a loss of power, and the imaginary Im (Z) causes a delay between current and voltage. Resistance obeys Ohm's law, so its impedance is the ratio between the amplitudes of voltage and current.

$$Z = Re\{z\} = R = V/I \quad (4)$$

This expression is valid for any combination of resistors if they can be combined into one resistance. For a capacitor, the current is proportional to the derivative of the voltage over time, so Ohm's law is invalid. The impedance of the capacitance will be equal to:

$$Z = -j(1/(2\pi fC)) \quad (5)$$

Thus, its impedance depends on the frequency and the phase is 90 °, that is, a capacitor is a purely reactance. The capacitor resistance decreases for high frequencies, but increases for low frequencies. Figure 3 shows a diagram of measuring the resistance of a human organ or any part of O.

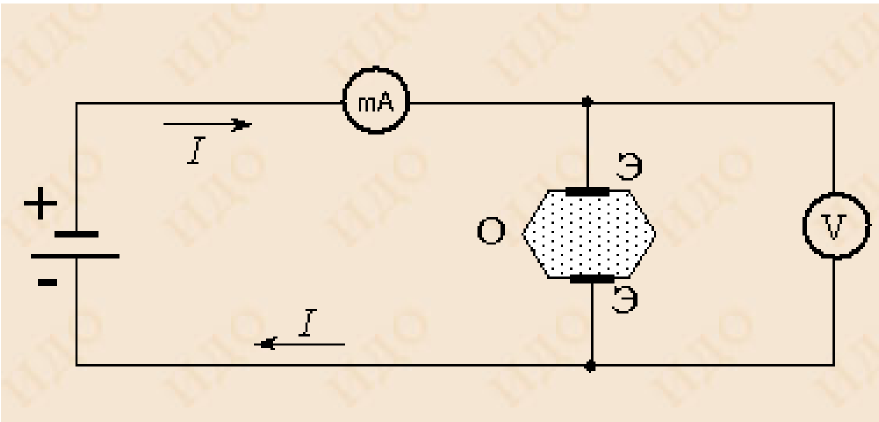

Figure 3 - Scheme of measuring organ resistance

The true resistance of this region, O, due to the arising polarization of tissues and the appearance of additional charges on the electrodes, is difficult to detect. For these reasons, direct current is not used, alternating current is used instead. When applying AC voltage to the electrodes $U = U_0 sinwt$ in the circuit of the investigated object O AC current flows, legally changing $I = I_0 \sin{(wt - \varphi_0)}$. Value

$Z = \frac{U_0}{I_0}$, there is resistance or can be called the impedance of the object and depends on the properties of the object itself, and on the frequency of the current. Cell membranes, also the interface between different tissues are similar to a capacitor, therefore, any part of the body has a more or less significant C. Capacitance R_c decreases with increasing AC frequency according to the law $R_c = \frac{1}{2\pi\nu C} = \frac{1}{\omega C}$.

Bioimpedance has a real and imaginary part. The real part of the extracellular space, the imaginary part is a biological membrane, that is, a cell. The frequency range for the studied biological objects is from 1 kHz to 1.3 MHz. As shown in Fig. 3, at a low frequency (less than 50 kHz), an electric current passes only through the extracellular space. With increasing current frequency, the total[20] electrical resistance of the body decreases. This is due to the capacitive properties of cell membranes.

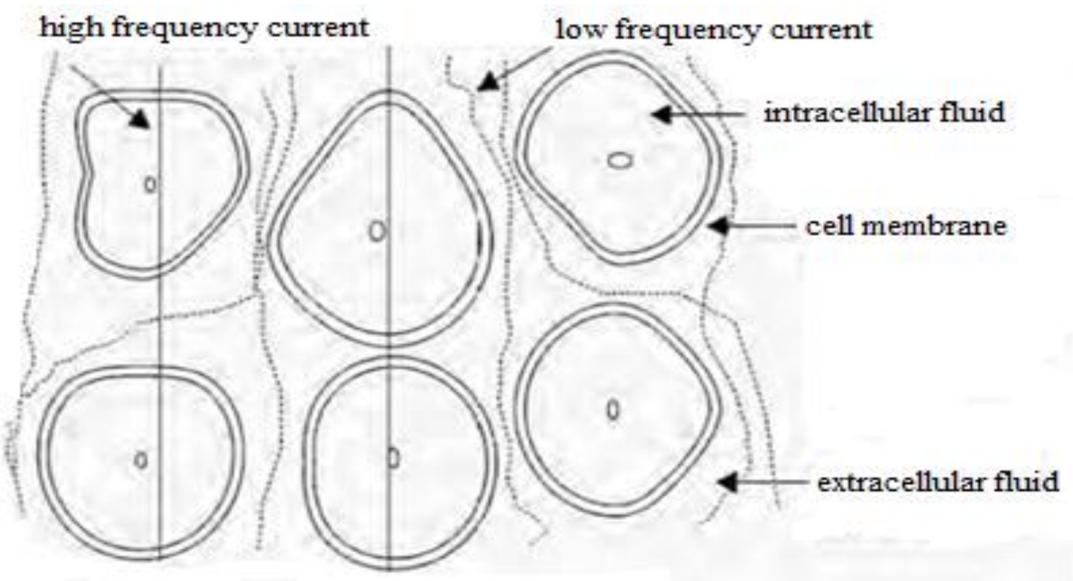

Figure 4 - The passage of electric current through the cells.

Currently, the method of measuring impedance is quite widely used in medicine and biology. The advantage of this method is that the voltages used (less than 50 mV) do not make significant changes in the physicochemical processes that occur in biological objects, and, moreover, do not damage them. The method has found wide application in the study of processes occurring in living tissues during a change in their physiological state, in pathological conditions, under the action of damaging factors: sweat, temperature, radiation,etc. In pathological processes in tissues, their electrical properties change: the membrane permeability increases and, as a result, ion fluxes increase and, consequently, the effect of polarization of interfaces is weakened. This leads to a drop in resistance and capacitance at low frequencies. At high frequencies, polarization of the interface is practically [21]absent, therefore, the high-frequency resistance does not significantly change. Thus, under the influence of damaging factors and with the death of tissue, the dispersion of its electrical parameters decreases. With complete death of the tissue, dispersion is absent.

Bioimpedance analysis at a single frequency, typically at a frequency of 50 kHz, is passed between surface electrodes placed on arms and legs. Electrodes are also used at other places, for example, legs to foot or from hand to hand electrodes. At a frequency of 50 kHz, strictly speaking, not a full suspended liquid is measured, but the resistance of extra-cellular and extra-cellular liquid is measured. Bioimpedance analysis at a single frequency allows you to evaluate fat-free mass and total suspended liquid.

2.2 Types of dispersions in biological tissues

In a healthy body, the cell membrane consists of a non-conductive layer, consisting of lipids, and protein molecules. Under the influence of alternating current, the structure of the cell membrane changes the reactive capacity of elements that behave like a capacitor. Biologically, the cell membrane is a selective semipermeable barrier, separating intracellular and extracellular space. It protects the inside of the cell, making possible the passage of certain substances for which it is permeable. The cell membrane retains the osmotic pressure and ion concentration gradient between the inside and extracellular spaces. This gradient creates the difference in electrical potential that is necessary for cell survival. Damage to the cell membrane, its functions, is fatal to the cell, as well as damage to the nucleus itself. Due to the high degree of polarization of membranes and electrodes, the measurement of the electrical conductivity of biological systems with direct current is extremely difficult. At low AC frequencies, most of the current flows through the intercellular spaces. As the frequency of the electric current increases, the reactance of the capacitance decreases, and the polarization phenomena decrease. The dependence of the resistance and capacitance of an object on frequency is called the dispersion[22]. In biological tissues, there are three types of dispersions — α, β, and γ — in the dependences of conductivity and permeability on frequency.

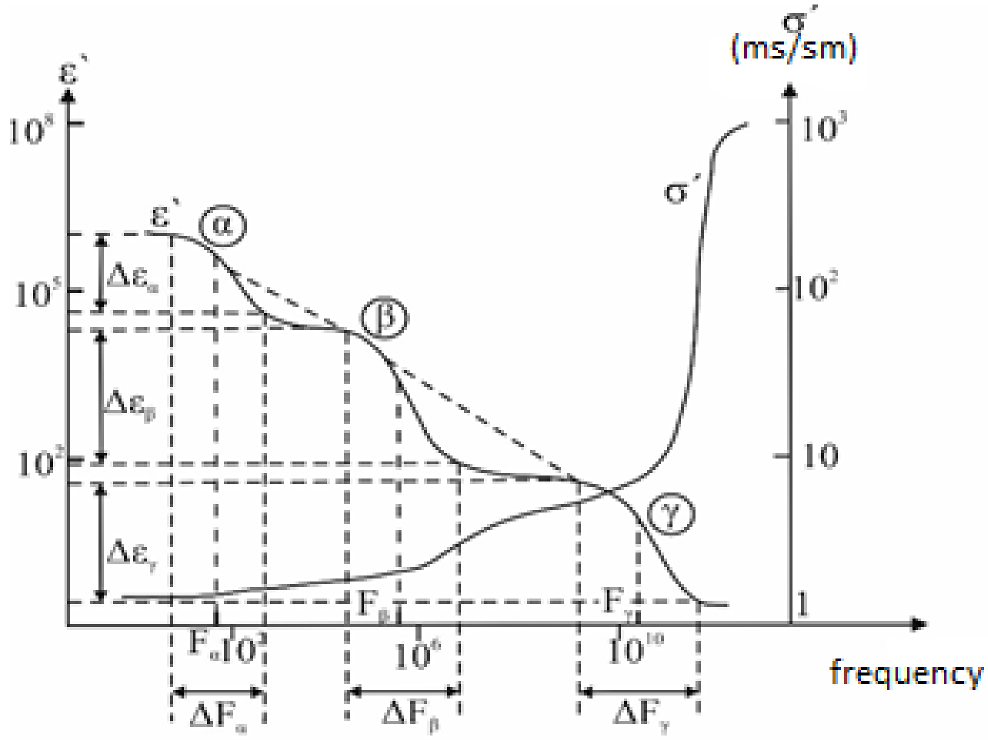

Figure 5 - Types of dispersions in biological tissues

This relationship is referred to as variance. At relatively low frequencies <1 MHz, tissue conductivity is determined by the conductivity of the intercellular fluid electrolyte. The total conductivity depends on the amount of intercellular space. In some cases, the so-called α-dispersion appears with an average frequency in the kilohertz range. It is assumed that the interaction between ions bound on slightly charged surfaces and biological membranes makes the main contribution to this type of dispersion. An additional contribution is made by the polarization of membrane proteins and lipids. At frequencies below the α-dispersion, the value of the relative dielectric constant increases sharply to 10*7. In the frequency range 3 kHz - 1 GHz, in biological materials observed β dispersion with an average frequency of 100 kHz - 10 MHz. Its presence is due to the interaction of intracellular and extracellular ions. At frequencies above β dispersion of the impedance of cell membranes can be neglected. Applied voltage causes current to flow through the extracellular space, as well as through the intracellular. View β-dispersions may be affected by side effects. for example, relaxation of amino acids or the presence of a charge in intracellular organelles. At frequencies above 1 GHz, biological tissues appear γ-dispersion, which is mainly determined by the relaxation of water molecules present in the tissues. In this frequency range, hydration membranes along lipid membranes can be investigated. The average frequency of 19 GHz is the relaxation frequency of free water. The frequency shift can be caused by the binding of proteins to water molecules. Hydrated proteins exhibit a wide range of frequencies from a few megahertz to GHz, which reflects the presence of charged macromolecules. In the most commonly used frequency range of 100 Hz - 10 MHz, the behavior of the impedance is determined by β-dispersion. A cell, the basic unit of biological tissues, consists of a phospholipid membrane, which separates its internal contents from the extracellular space. The extracellular space can be represented as an electrolyte, where most of the ions are represented by Na + and Cl- ions. Therefore, the electrical properties of tissues depend on physical and chemical parameters, which determine concentration or motility. Temperature also plays an important role in ionic conductivity [23]. The viscosity of the solution decreases with increasing temperature, while increasing the mobility of the ions and thus reducing the resistance. The pH value in most tissues is in the range of 6-8, so the H + concentration is low and does not make a significant contribution to conductivity. The concentration of ions inside the cell is comparable to extracellular, only the main charge carriers are K +, HPO42-, SO42- ions, proteins and organic acids. In addition, there are numerous structures within the cell that have their own membranes. These membranes also have poor conductivity. Therefore, the impedance of the intracellular medium has capacitive properties. The cell membrane is a double layer of lipids. Its thickness is about 7 nm; therefore, water and lipid molecules can pass through it; however, it represents a serious barrier to charged ions. Together with the extracellular and intracellular fluid, the membrane represents a capacitor with a capacitance of approximately 1 μF / cm2. Various proteins, transport organelles, as well as ion channels and pumps, which play a major role in cell activity, are embedded in the membrane.

2.3 Equivalent Biological Object Schemes

To simulate the electrical properties of biological tissues, resistors that have active resistance are used, and capacitors are carriers of capacitive resistance. As a model using equivalent electrical circuits. Let us consider some of them (Fig. 6). [9]

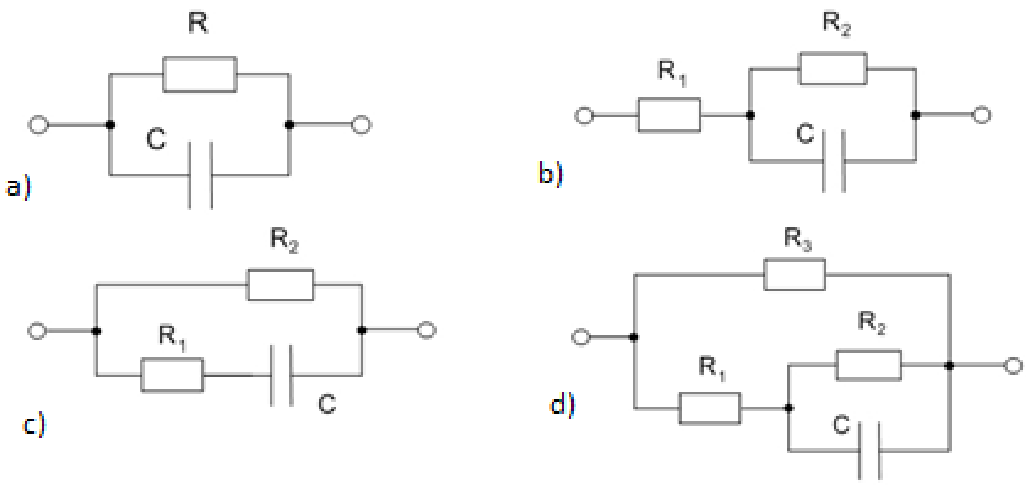

Figure 6 - Electrical equivalent circuit of a biological object:

a) in the low-frequency range of frequencies; b) when studying the surface layers of the skin and subcutaneous tissue; c) muscle tissue in combination with other components such as fat, blood, etc .; d) deeper layers of the body and internal organs

In addition to the electrical properties of biological tissue in the skin-electrode contact, it is necessary to take into account the characteristics of other components - the near-electrode fluid and the electrode. Due to the impossibility of ensuring a sufficiently stable and good contact between the electrode and the skin over its entire surface, various contact means are placed between the electrode and the skin: electrode pastes, cloth pads impregnated with physiological saline NaCl, etc. To register the biopotential, it is necessary to use at least two electrodes, which must be taken into account when developing equivalent skin-electrode contact schemes.

4. Financial management, resource efficiency and resource saving

The purpose of this section discusses the issues of competitiveness, resource efficiency and resource saving, as well as financial costs regarding the object of study of Master's thesis. Competitiveness analysis is carried out for this purpose. SWOT analysis helps to identify strengths, weaknesses, opportunities and threats associated with the project, and give an idea of working with them in each particular case. For the development of the project requires funds that go to the salaries of project participants and the necessary equipment, a complete list is given in the relevant section. The calculation of the resource efficiency indicator helps to make a final assessment of the technical decision on individual criteria and in general.

Achieving the goal is provided by solving the following problems:

• development of a common economic project idea, the formation of a project concept;

• organization of work on a research project;

• identification of possible alternatives for conducting research;

• research planning;

4.1 Potential consumers of research results

Radiation therapy, like any type of treatment, can be accompanied by both local (in the field of exposure to radiation on the tissue) as well as a common side effect. Side effects of radiotherapy are most often manifested in tissues and organs exposed to direct exposure to radiation.

It is necessary to determine the frequency and degree of radiation damage to normal tissues (skin, subcutaneous tissue, lungs) after complex treatment with fast neutrons of 6.3 MeV in patients with primary locally advanced breast cancer and with local relapses to us.

The work is aimed at assessing the possibility of using bioimpedance spectrometry for measuring tissue damage after radiation therapy.

In this work, the possibilities of using bioimpedance spectrometry for measuring tissue damage after radiation therapy. However, at this stage it is too early to talk about the commercial potential of this study. In this regard, the analysis of potential consumers has not been done.

As you know, neutron irradiation leads to serious damage to biological tissues. in the measurement, the phase angle versus frequency was used for irradiated tissues.

Bioimpedance spectrometry is suitable for measuring tissue damage after radiation therapy for breast cancer. This device is compact, and it can be used in any oncology clinic after radiation therapy courses. The project is economically useful, since the construction of the device takes less cost.

4.2 Competitiveness analysis of technical solutions

In order to find sources of financing for the project, it is necessary, first, to determine the commercial value of the work. Analysis of competitive technical solutions in terms of resource efficiency and resource saving allows to evaluate the comparative effectiveness of scientific development. This analysis is advisable to carry out using an evaluation card.

Analyzing competitive technical solutions from the point of view of efficient use of resources and resources, one can evaluate the comparative effectiveness of scientific development and determine the direction for increasing its future. This analysis was carried out using the scorecard, which is shown in the table 1. P_f product that is the result of this work, P_{i1} competitive development: P_{i1} WK 6515P, manufactured by Wayne Kerr Electronics (Wayne Kerr).

The evaluation scorecard for the analysis is presented in Table 6. The position of the development and competitors is evaluated expertly on each indicator on a five-point scale, where 1 is the weakest position and 5 the strongest. The weights of indicators determined by experts, in total should be 1. Analysis of competitive technical solutions is determined by the formula:

$$C = \sum W_i \cdot P_i,, \qquad (1)$$

C - the competitiveness of research or a competitor;

Wi– criterion weight;

Pi – point of i-th criteria.

You can use the following criteria for the model of expert evaluation:

- Ease of use (meets customer requirements)
- Improving user productivity
- Functional capacity
- Easy operation
- Safety

Table 1 - Evaluation card for comparison of competitive technical solutions

Evaluation criteria	**Criterion weight**	**Points**		**Competitiveness**	
		P_f	P_{i1}	C_f	C_{i1}
Technical criteria for evaluating resource efficiency					
1. Ease of use (meets customer requirements)	0,15	5	4	0,75	0,6
2. Improving user productivity	0,13	5	5	0,65	0,65
3. Functional capacity	0,17	4	4	0,68	0,68
4. Easy operation	0,12	5	4	0,6	0,48
5. Safety	0,18	4	4	0,72	0,72
Economic criteria for performance evaluation					
1. Development cost	0,08	5	4	0,4	0,32
2. Market penetration rate	0,07	4	4	0,28	0,28
3. Expected lifecycle	0,1	4	4	0,4	0,4
Total	**1**	**36**	**33**	**4,48**	**4,05**

As the analysis showed, the use of bioimpedance spectrometry is more competitive, since the measurement results showed a rather high reliability of measuring the electrical characteristics of tissues.

4.3 SWOT analysis

Complex analysis solution with the greatest competitiveness is carried out with the method of the SWOT analysis: Strengths, Weaknesses, Opportunities and Threats. The analysis has several stages. The first stage consists of describing the strengths and weaknesses of the project, identifying opportunities and threats to the project that have emerged or may appear in its external environment. The second stage consists of identifying the compatibility of the strengths and weaknesses of the project with the external environmental conditions. This compatibility or incompatibility should help to identify what strategic changes are needed.

Strengths are factors that characterize the competitive side of a research project. Strengths indicate that the project has a distinctive advantage or special resources that are special in terms of competition. In other words, strengths are resources or opportunities that the project management has and which can be effectively used to achieve the goals.

Weaknesses are a lack, omission or limitation of a research project that impedes the achievement of its objectives. This is something that does not work well within the project or where it has insufficient capabilities or resources compared to competitors.

Opportunities include any preferable situation in the present or future that arises in the environment of the project, for example, a trend, change, or perceived need that supports the demand for project results and allows project management to improve their competitive position.

A threat is any undesirable situation, tendency or change in the environmental conditions of a project that is destructive or threatening in nature for its competitiveness in the present or in the future. A threat can be a barrier, restriction, or anything else that could cause problems, destruction, harm, or damage to the project.

Table 2 presents the SWOT analysis in the form of a table, as well as the results of the intersections of the parties, opportunities and threats.

Table 2 - SWOT analysis

	Strengths: S1. Measurement stability S2. No complexity of processing results S3. The ability to attract consumers S4. The estimated market price of prototypes developed abroad to analyze impedance on other measurement methods is too high.	**Weaknesses:** W1. To reduce the error, large measurement statistics are needed. W2. The complexity of the design and design of models of the device for analysis of the electrical properties of materials
Opportunities: O1. The emergence of additional demand for a new product. O2. development of a device for measuring tissue damage O3. Collaboration with a number of new organizations.	1.The simplicity of obtaining and processing the results will enable us to increase the demand for our product. 2. Reliability and safety of the method will make it possible to establish cooperation with a number of new organizations.	1.Small measurement statistics lead to large measurement error

Threats: T1. High competition. T2. Lack of funding from both the university and the states	1.Demonstrate the simplicity of the device to customers and focus on portability and low cost. 2. The analysis of materials provides an opportunity to enter the market.	1.Simplicity and accuracy of measurements give an advantage over competitors in the market. 2. Conclusion of financial agreements with external organizations by demonstrating possible device models.

Based on the results of the analysis, it can be concluded that the most optimal strategy for developing a product on the market is a joint business strategy.

4.4 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. In the initiation processes, the initial purpose and content are determined and the initial financial resources are fixed. The internal and external stakeholders of the project who will interact and influence the overall result of the research project are determined.

Table 3 - Stakeholders of the project

Project stakeholders	**Stakeholder expectations**
Russian oncology clinics and dispensaries	New innovative technique for measuring tissue changes after radiation therapy, easy to use and inexpensive.
Russian Cancer Research Institutes	Enhanced ability to determine the degree of exposure to radiation exposure for new research in this area.

Oncologists	Determination of the effects of radiation therapy on the irradiation area. Increased tumor control and, as a result, improved quality of treatment.
Oncological patients	Determination of the state of the area of radiation after radiation therapy

4.4.1 Purpose and results of the project

This section provides information about project stakeholders, the hierarchy of project goals, and criteria for achieving goals.

Project stakeholders are understood as persons or organizations that are actively involved in the project or whose interests can be affected both positively and negatively during the execution or as a result of the completion of the project. Information on stakeholders of the project is presented in table 4.

Table 4 - Purpose and results of the project

Purpose of project:	Show the possibility of using bioimpedance spectrometry to measure tissue damage after radiation therapy.
Expected results of the project:	Accurate assessment of the radiation response to the irradiated area. Assessment of changes in the electrical properties of tissues before and after radiation therapy. Reduction of complications after radiation therapy.
Criteria for acceptance of the project result:	Bioimpedance spectrometry device should have a compact form for ease of use to assess damaged tissue Data processing accuracy
Requirements for the project result:	The results obtained must satisfy the acceptance criteria of the project result.
	Research results must be accurate
	If unsatisfactory results are obtained, additional studies should be carried out using other radiation sources.
	The results of scientific research should be presented at one of the all-Russian / regional conferences and have a publication in one of the scientific journals.

4.4.2 The organizational structure of the project

It is necessary to solve the some questions: who will be part of the working group of this project, determine the role of each participant in this project, and prescribe the functions of the participants and their number of labor hours in the project.

Table 5- Project working group

№	Participant	Role in the project	Functions	Labor time, hours.
1.	Aleinik. A.N. associate professor	Adviser project	Responsible for the implementation of the project within the specified resource limits, coordinates the activities of project participants.	216
2.	Turgunova N.D. Nuclear physycist	Administrant project	Responsible for helping the master in the development of a device for bio-impedance spectrometer	68
3.	Bissenbayeva B.K. student	Administrant project	Writing a review of literary sources and technical literature. Carrying out experimental measurements and processing of the obtained data. Drawing up a report on research work.	564
TOTAL:				848

4.5 Planning GQW

Graduation qualification work (GQW)-is a work of a scientific nature related to scientific research, conducting research in order to obtain scientific generalizations, finding principles and ways of creating (modernizing) products, it includes:

- fundamental research carried out in order to expand scientific knowledge, phenomena and patterns of their development, regardless of their specific practical application;
- exploratory research carried out in order to find ways to use the identified phenomena and patterns in a particular field of science and technology to create fundamentally new products, materials and technologies;
- applied research aimed at solving scientific problems, improving methods in order to obtain specific results used in experimental design when creating scientific and technical.

4.5.1 The structure of work within GQW

Planning a set of proposed works is carried out in the following order:

• determination of the structure of work within the framework of scientific research;

• identification of participants in each work;

• setting the duration of work;

• building a schedule for research.

To carry out scientific research, a working group is formed, which may include researchers and teachers, engineers, technicians and laboratory assistants, the number of groups may vary.

For each type of planned work, the corresponding position of performers is established. In this section, it is necessary to compile a list of stages and works within the framework of a scientific research, to distribute performers by type of work. An approximate procedure for the preparation of stages and work, the distribution of performers for these types of work is given in table 6.

Table 6 - a List of stages, works and distribution of performers

Main stages	№ work	Work Content	Executive position
Development of technical specifications	1	The choice of research direction.	Supervisor
The choice of research direction	2	Drafting and approval of technical specifications.	Supervisor Student
	3	Scheduling.	Supervisor Student
Theoretical and experimental research	4	Review of literature and technical literature.	Student
	5	Experimental measurements and data processing.	Supervisor Student
	6		Supervisor Student
Summary and assessment of results	7	Comparison of model results and experimental results.	Student
	8	Irradiation of cells in a culture bottle and processing of the obtained data.	Supervisor Consultant Student
Reporting on GQW	9	Drawing up an explanatory note.	Student
	10	Preparing for the defense.	Supervisor Student

4.5.2 Determination of the complexity of execution GQW

Labor costs in most cases form the bulk of the development cost, so an important point is the determination of the complexity of the work of each of the participants in the scientific research. The complexity of scientific research is estimated expertly in person-days and is probabilistic in nature, because depends on many difficult factors to consider. To determine the expected (average) value of the complexity t_{eli} then the following formula is used:

$$t_{eli} = \frac{3t_{\min i} + 2t_{\max i}}{5} \quad (2)$$

where t_{eli} is the expected laboriousness of the implementation of the i-th work, person-day;

t_{mini} –the minimum possible complexity of the performance of a given i-th job (optimistic assessment: assuming the most favorable set of circumstances), person-day;

t_{maxi} – the maximum possible complexity of a given i-th job (pessimistic assessment: assuming the most unfavorable set of circumstances), person-day

Based on the expected complexity of the work, the duration of each work in working days is determined T_p , taking into account the parallel work performed by several performers.

$$T_{w_i} = \frac{t_{eli}}{n_i} \quad (3)$$

where T_{w_i}- the duration of one work, working days;

t_{eli} – the expected complexity of one job, person-days;

n_i – the number of performers performing simultaneously the same work at this stage, people;

In the course of this work, the number of people performing each of the work at each stage is equal to one.

4.5.3 Development of a schedule GQW

In the course of this work, a tape schedule for GQW in the form of Gantt charts was built. Gantt chart - a horizontal strip chart on which work on a topic is represented by time-lapse segments characterized by the start and end dates of these works.

For the convenience of constructing a calendar schedule, the duration of the stages in working days is translated into calendar days and calculated according to the following formula:

$$T_{ci} = T_{wi} \cdot k \quad (4)$$

where T_{ci} – the duration of one work, (calen.day);

T_{wi} – the duration of one work, (working days);

k – calendar coefficient, designed to translate working time into calendar.

The calendar coefficient is calculated according to the following formula:

$$k = \frac{T_{cy}}{T_{cy} - T_{off} - T_h} \quad (5)$$

where, T_{cy} – the number of calendar days in a year (T_{cy}= 365 days);

T_{off} – number of days off per year (T_{off}= 52 days);

T_h – number of holidays per year (T_h= 14 days);

The calculated values in calendar days for each work T_{ci} rounded to an integer.

$$k = \frac{365}{365-52-14} = 1{,}22$$

All calculated values are summarized in table 7.

Table 7 - Temporary performance

№	**The complexity of the work**			**Performers**	**Duration works T_{wi}, day**	**Duration works $T_{кi}$, day**
	t_{min}, per-day	**t_{max}, per-day**	**t_{eli}, per-day**			
1	3	7	4,6	Supervisor	4,6	6
2	2	4	2,8	Supervisor Student	1,4	2
3	2	4	2,8	Supervisor Student	1,4	2
4	15	40	25	Student	25	31
5	2	7	4	Consultant Student	2	2
6	20	45	30	Supervisor Student	15	18
7	5	15	9	Student	9	11

8	20	40	28	Supervisor Consultant Student	9,3	11
9	21	35	26,6	Student	26,6	32
10	5	14	8,6	Supervisor Student	4,3	5
Total:	**95**	**211**	**141,4**	**-**	**34,6/11,3/94**	**26/29/115**

Based on table 7, a calendar schedule is built. The schedule is built for the maximum duration of work within GQW based on table 8, disaggregated by months and decades (10 days) for the period of time of certification. At the same time, the work on the chart is highlighted in different colors, depending on the performers responsible for a particular work.

Table 8 - Gantt chart

№	**Work Content**	**Executive position**	**Tк**	**Duration of work**											
				February			March			April			May		
				1	2	3	1	2	3	1	2	3	1	2	3
1	The choice of research direction.	Supervisor	6												
2	Drafting and approval of technical specifications.	Supervisor Student	2												
3	Related scheduling	Supervisor Student	2												
4	Review of literature and technical literature.	Student	31												
5	Experimental measureme	Supervisor Student	2												

	nts and data processing.														
6	Practical calculation	Supervisor Student	18												
7	Comparison of model results and experimental results.	Student	11												
8	Compilation and execution of calculations	Supervisor Consultant Student	11												
9	Drawing up an explanatory note.	Student	32												
10	Preparing for the defense.	Supervisor Student	5												

4.5.4 Costs of special equipment

This point includes the costs associated with the acquirement of special equipment (instruments, stands, devices and mechanisms) necessary to carry out work on a specific topic.

$$A = \frac{C_{\text{перв}} * \text{Н}_\text{а}}{100} \qquad (6)$$

A - annual amount of depreciation;

$C_{перв}$ - initial cost of the equipment;

$\text{Н}_\text{а} = \frac{100}{\text{Т}_{\text{сл}}}$ - the rate of depreciation, where $T_{сл}$ is the service life.

All calculations for the acquisition of equipment available in the organization, but used to perform these experiments, are summarized in table 8.

Table 9 - Costs of special equipment (+software)

№	Equipment identification	Quantity of equipment	Price per unit, rub.	Service life, years	Total cost of equipment, t housand rub.
1.	Laptop Lenovo Ideapad 330	1	15000	10	410
2.	Soldering device	1	2000	5	109
Total:			**17000**		**519**

4.5.5 Scientific and technical research budget

The amount of costs associated with the implementation of this work is the basis for the formation of the project budget. This budget will be presented as the lower limit of project costs when forming a contract with the customer.

To form the final cost value, all calculated costs for individual items related to the manager and the student are summed.

In the process of budgeting, the following grouping of costs by items is used:

Material costs of scientific and technical research;

costs of special equipment for scientific work (Depreciation of equipment used for design);

basic salary;

additional salary;

labor tax;

overhead.

4.5.6 Calculation of material costs

The calculation of material costs is carried out according to the formula:

$$C_m = (1 + k_T) \cdot \sum_{i=1}^{m} P_i \cdot N_{consi} \, , \qquad (7)$$

where m – the number of types of material resources consumed in the performance of scientific research;

N_{consi} – the amount of material resources of the i-th species planned to be used when performing scientific research (units, kg, m, m^2, etc.);

P_i – the acquisition price of a unit of the i-th type of material resources consumed (rub./units, rub./kg, rub./m, rub./m^2, etc.);

k_T – coefficient taking into account transportation costs.

Prices for material resources can be set according to data posted on relevant websites on the Internet by manufacturers (or supplier organizations).

Table 10 - Material costs

Name	Unit	Amount	Price per unit, rub.	Material costs, rub.
Atmega16	piece	1	150	150
Usb(Rs232)	piece	1	510	510
AD5933	piece	1	701,4	701,4
Resistors	piece	30	8	320
Capacitor	piece	16	5	80
Total				1761,4

Calculation of costs for special equipment for scientific (experimental) work

Expenses for special equipment:

$$D = \frac{N_d * C * T_0}{365} \quad (8)$$

Where D- depreciation charges, rub.;

C- cost of equipment used, rub.;

N_d- annual depreciation rate;

T_0- time of use of equipment, days.

$$D = \frac{0.1 * 1067451 * 10}{365} = 2924$$

equipment costs amounted to 2924 rub.

4.5.7 Basic salary

This point includes the basic salary of participants directly involved in the implementation of work on this research. The value of salary costs is determined based on the labor intensity of the work performed and the current salary system

The basic salary (S_b) is calculated according to the following formula:

$$S_b = S_a \cdot T_w \quad (9)$$

where Sb – basic salary per participant;

T_w – the duration of the work performed by the scientific and technical worker, working days;

Sa - the average daily salary of an participant, rub.

The average daily salary is calculated by the formula:

$$S_d = \frac{S_m \cdot M}{F_v}, \quad (10)$$

где S_m – monthly salary of an participant, rub .;

M – the number of months of work without leave during the year:

at holiday in 48 days, M = 11.2 months, 6 day per week;

F_v – valid annual fund of working time of scientific and technical personnel (251 days).

Table 11 - The valid annual fund of working time

Working time indicators	supervisor	student
Calendar number of days	365	365
The number of non-working days - weekend - holidays	52 14	52 14
Loss of working time - vacation - sick absence	48	48
The valid annual fund of working time	251	251

Monthly salary is calculated by formula:

$$S_{month} = S_{base} \cdot \left(K_{premium} + K_{bonus}\right) \cdot K_{reg} \quad (11)$$

where S_{base} – base salary, (the salary of an assistant professor, candidate of sciences is 35120 rubles);

$k_{premium}$ – premium rate (0,3);

k_{bonus} – bonus rate (0,2-0,5);

k_{reg} – regional rate (1,3).

Table 12 - Calculation of the base salaries

Performers	S_{base}, rubles	$k_{premium}$	k_{bonus}	k_{reg}	S_{month}, rub.	W_d, rub.	T_p, work days	W_{base}, rub.
Supervisor	35120			1,3	45 656	1 891	34,6	65428
Consultant	21760				28 288	1 172	11,3	13243
Student	17890				23257	963	94	90581
Total:								**169252**

4.5.8 Additional salary

This point includes the amount of payments stipulated by the legislation on labor, for example, payment of regular and additional holidays; payment of time associated with state and public duties; payment for work experience, etc.

Additional salaries are calculated on the basis of 10-15% of the base salary of workers:

$$W_{add} = k_{extra} \cdot W_{base} \qquad (12)$$

where W_{add} – additional salary, rubles;

k_{extra} – additional salary coefficient (10%);

W_{base} – base salary, rubles.

Table 13 - Salary of performers of scientific research work

Wage	**Supervisor**	**Consultant**	**Student**
Basic salary, rub / month	65428	13243	90581
Additional salary, rub	6542	1324	9058
Total:	**71970**	**14567**	**99639**

4.5.9 Labor tax

Tax to extra-budgetary funds are compulsory according to the norms established by the legislation of the Russian Federation to the state social insurance (SIF), pension fund (PF) and medical insurance (FCMIF) from the costs of workers.

Payment to extra-budgetary funds is determined of the formula:

$$P_{social} = k_b \cdot (W_{base} + W_{add}) \qquad (13)$$

where k_b – coefficient of deductions for labor tax.

In accordance with the Federal law of July 24, 2009 No. 212-FL, the amount of insurance contributions is set at 30%. Institutions conducting educational and scientific activities have rate - 27.1%.

Contributions to extra-budgetary funds are recommended to be presented in tabular form (table 14).

Table 14 - Contributions to extrabudgetary funds

Performers	**Basic salary, rub.**	**Additional salary, rub.**
Supervisor	65428	6542
Consultant	13243	1324
Student	90581	9058
Extrabudgetary fund allocation rate	0,271	
Total:	**45867**	

4.5.10 Overhead costs

Overhead costs take into account other expenses of the organization that are not included in the previous items of expenses: printing and photocopying of research materials, payment for communication services, electricity, postal and telegraph costs, reproduction of materials, etc.

Electricity costs are calculated by the formula:

$$C_{el} = S_{el} * F_{eq} * \mathrm{P} \tag{14}$$

Where S_{el}- tariff for industrial electricity (5.8 rubles / kWh);

P,kW - equipment power (laptop);

F_{eq}, h - the time of use of the equipment.

Table 15 - the cost of electricity

Name	**Working hours**	**Power consumption, kW**	**Price per 1 kW, rub.**	**Electricity costs (S_{el}), rub.**
1. TheratronEquinox 100 gamma therapeutic apparatus	20	10	5,8	1 160
2.Cylindrical ionization chamber FC65-G	10	0,004		0,23
3.PC	10	0,004		0,23
Total:				**1160.46**

When performing the work, a laptop with an average power of 90 W (0.09 kW) was used.

Cost of energy spent on a laptop:

C_{el}l=5.8 · 0.09 · 294 {49 working days ∗ 6} = 153.47 rubles.

Cost of energy spent on a soldering device with an average power of 40 W (0.04 kW):

C_{el}s=5.8 · 0.04 · 48 {8 working days ∗ 6} = 11.14 rubles.

C_{el}=C_{el}l+C_{el}p=153.47 + 11.14 = 161.61 rubles.

Table 16 - Electricity Costs

Denomination	**Working hours**	**Power consumption, kW**	**Price per 1 kW, rub.**	**Electricity costs , rub.**
1.Laptop	0.09	294	5,8	153.47
2. Soldering device	0.04	48		11.14
Total:				**161.1**

4.5.11 Formation of budget costs

The calculated cost of research is the basis for budgeting project costs. Determining the budget for the scientific research is given in the table 17.

Table 17 - Items expenses grouping

Name	**Cost, rubles**
Material costs	1761,4
Costs of special equipment	519000
Basic salary	169252
Additional salary	16925
Labor tax	45867
Overhead	161,1
Total planned cost	**752966,5**

During the implementation of the economic part, calculations were made of the planned cost of the study and the time required to carry out this work. The planned cost of the work is 752966,5 rubles, the main component of which is the wages of employees.

4.6 Definition of resource (resource-saving), financial, budgetary, social and economic effectiveness of the study

The determination of effectiveness is based on the calculation of the integral indicator of the effectiveness of scientific research. Its location is associated with the determination of two weighted average values: financial efficiency and resource efficiency.

The integrated financial development indicator is defined as:

$$I_{fin}^{exei} = \frac{\Phi_{pi}}{\Phi_{max}} \quad (15)$$

Where I_{fin}^{exei} - integrated financial development indicator;

Φ_{pi}- the cost of the i-th embodiment;

Φ_{max} - the maximum cost of the execution of a research project (including analogues).

Since the development has one execution, then

$$I_{fin}^{d} = \frac{104877}{212036} = 0.59$$

For analogue, respectively:

$$I_{fin}^{a} = \frac{212036}{212036} = 1$$

The integral indicator of resource efficiency of options for the execution of the object of study can be determined as follows:

WhereI_{pi} - integral indicator of resource efficiency for the i-th version of the development;

a_i - weight coefficient of the i-th development option;

b_i - a point assessment of the i-th version of the development, is established by experts on the selected assessment scale;

n –number of comparison parameters.

The calculation of the integral resource efficiency indicator of this study is presented in the form of table 18:

Table 18 - Comparative evaluation of the characteristics of the project options

Object of study / **Criteria**	**Parameter Weight Factor**	**Exe.1 (Current project)**	**Exe.2 (Analog)**
1. Promotes user productivity	0,1	5	4
2. Ease of use (meets customer requirements)	0,15	4	4
3. Noise immunity	0,15	4	5
4. Energy saving	0,20	4	3
5. Reliability	0,25	4	4
6. Material consumption	0,15	4	4
Total:	**1**	4,1	3,95

$$I_{\text{p}-exe.1} = 5 * 0{,}1 + 4 * 0{,}15 + 4 * 0{,}15 + 4 * 0{,}2 + 4 * 0{,}25 + 4 * 0.15 = 4{,}1$$

$$I_{\text{p}-exe.2} = 4 * 0{,}1 + 4 * 0{,}15 + 5 * 0{,}15 + 3 * 0{,}2 + 4 * 0{,}25 + 4 * 0.15 = 3{,}95$$

Integral performance indicator of development options I_{pi} is determined on the basis of an integrated indicator of resource efficiency and an integrated financial indicator according to the formula:

$$I_{exei} = \frac{I_{\text{p}-exei}}{I_{fin\text{p}}^{exei}} \quad (16)$$

Comparison of the integrated indicator of the effectiveness of development options will allow you to determine the comparative effectiveness of the project (table 19) and choose the most appropriate option from the proposed ones. Comparative effectiveness of the project (E_{mean}):

$$E_{mean} = \frac{I_{exe1}}{I_{exe2}} \tag{17}$$

Table 19 - Comparative development efficiency

№	**Indicators**	**Exe. 1**	**Exe. 2**
1.	Integrated Financial Development Indicator	0,49	1
2.	Integrated Performance Indicator	8,37	3,95
3.	Comparative Performance Options	2,12	1

Comparing the values of integral performance indicators, it can be noted that the current project is a more effective option for solving the technical task posed in bachelor's work from the position of financial and resource efficiency.

5. Social responsibility

5.1 Introduction

Bioimpedance analysis (BIA) is a contact method for measuring the electrical conductivity of biological tissues, which makes it possible to assess a wide range of morphological and physiological parameters of the body. Bioimpedance analysis measures the active and reactive resistance of the human body and or its segments at various frequencies. Body composition characteristics such as fatty, cellular and musculoskeletal mass, volume and distribution of water in the body were calculated based on them. For bioimpedance measurement, an apparatus called a bioimpedance meter is used. This equipment was originally designed to assess tissue damage during irradiation. This will allow avoid unnecessary radiation therapy sessions. Today, bioimpedance analysis is successfully used by doctors of different specialties: nutritionists, endocrinologists, doctors of other areas. The technique provides the doctor with a large amount of valuable information, indicates the need for laboratory and functional studies, helps in determining treatment tactics.

5.2 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 [1].

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.

5.3 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.

5.4 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 .

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.

5.4.1 Analysis of harmful and dangerous factors that can create object of investigation

The object of research is a bioimpedance spectrometer for measuring physiological tissue changes after radiation therapy. The probe current source is the most important component of a bio-impedance spectrometer - accuracy, stability, reproducibility of measurement results, and the frequency and dynamic range of the entire device depend on its characteristics.

During measurements, direct current and current cannot be used. Low frequency, because at the point of contact of the electrode with the skin begin electrochemical reactions, and measurements become impossible. Moreover, direct currents of more than 100 μA can cause serious damage, while alternating current with a frequency of 10 ... 100 kHz and forceup to 5 mA does not cause any biological effect. The object of the study is "bioimpedance spectrometry to assess tissue damage after radiation therapy." the object of study cannot cause harmful and dangerous factors.

5.4.2. 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 20.

Table 20 - 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
2. Excessive noise		+	+	
3.Increased level of electromagnetic radiation	+	+	+	

4.Insufficient illumination of the working area		+	+	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.
5. Abnormally high voltage value in the	+	+	+	Sanitary rules GOST 12.1.038-82

circuit, the closure which may occur through the human body				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 [2] and are given in Table 21.

Table 21 - Optimal and permissible parameters of the microclimate

Period of the year	Temperature, ^{C}	Relative humidity,%	Speed of air movement, m/s
Cold and changing of seasons	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, the organs of hearing and the whole body through the central nervous system. It result in weakened attention, deteriorated memory, decreased response, and increased number of errors in work. Noise can be generated by operating equipment, air conditioning units, daylight illuminating devices, as well as spread from the outside. When working on a PC, the noise level in the workplace should not exceed 50 dB.

Increased level of electromagnetic radiation

The screen and system blocks produce electromagnetic radiation. Its main part comes from the system unit and the video cable. According to [2], the intensity of the electromagnetic field at a distance of 50 cm around the screen along the electrical component should be no more than:

- in the frequency range 5 Hz - 2 kHz - 25 V / m;
- in the frequency range 2 kHz - 400 kHz - 2.5 V / m.
- The magnetic flux density should be no more than:
- in the frequency range 5 Hz - 2 kHz - 250 nT;
- in the frequency range 2 kHz - 400 kHz - 25 nT.

Abnormally high voltage value in the circuit

Depending on the conditions in the room, the risk of electric shock to a person increases or decreases. Do not operate the electronic device in conditions of high humidity (relative air humidity exceeds 75% for a long time), high temperature (more than 35 ° C), the presence of conductive dust, conductive floors and the possibility of simultaneous contact with metal components connected to the ground and the metal casing of electrical equipment. The operator works with electrical devices: a computer (display, system unit, etc.) and peripheral devices. There is a risk of electric shock in the following cases:

- with direct contact with current-carrying parts during computer repair;

- when touched by non-live parts that are under voltage (in case of violation -of insulation of current-carrying parts of the computer);
- when touched with the floor, walls that are under voltage;
- short-circuited in high-voltage units: power supply and display unit.

Table22 - Upper limits for values of contact current and voltage

	Voltage, V	Current, mA
Alternate, 50 Hz	2	0.3
Alternate, 400 Hz	3	0.4
Direct	8	1.0

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%.

5.4.3 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.

Increased level of electromagnetic radiation

There are the following ways to protect against EMF:

- increase the distance from the source (the screen should be at least 50 cm from the user);

- the use of pre-screen filters, special screens and other personal protective equipment.

When working with a computer, the ionizing radiation source is a display. Under the influence of ionizing radiation in the body, there may be a violation of normal blood coagulability, an increase in the fragility of blood vessels, a decrease in immunity, etc. The dose of irradiation at a distance of 20 cm to the display is 50 μrem / hr. According to the norms [2], the design of the computer should provide the power of the exposure dose of x-rays at any point at a distance of 0.05 m from the screen no more than 100 μR / h.

Fatigue of the organs of vision can be associated with both insufficient illumination and excessive illumination, as well as with the wrong direction of light.

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) [3].

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.

5.5 Electrical safety

Depending on the conditions in the room, the risk of electric shock increases or decreases. You should not work with computers in conditions of high humidity (relative humidity for a long time exceeding 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 casing of electrical equipment. The operator works with electrical appliances: a computer (display, system unit, etc.) and peripheral devices. Danger of electric shock exists in the following cases:

- with direct contact with live parts during repair;
- when touching live parts that are energized (in case of violation of insulation of live parts);
- when touching the floor, walls that have turned on under stress;
- in case of short circuit in high-voltage blocks: power supply unit and display scan unit.

Electric current passing through the human body has a thermal, chemical and biological effect. The thermal (thermal) effect is manifested in the form of burns on the skin area, overheating of various organs, as well as ruptures of blood vessels and nerve fibers resulting from overheating. Chemical (electrolytic) action leads to electrolysis of blood and other solutions contained in the human body, which leads to a change in their physico-chemical compositions, and hence to a disruption in the normal functioning of the body.

Measures to ensure electrical safety of electrical installations:

- disconnection of voltage from live parts on which or near which the work will be carried out, and measures to ensure the impossibility of supplying voltage to the place of work;
- hanging posters indicating the place of work;
- grounding of the enclosures of all installations through a neutral wire;
- coating metal surfaces of instruments with reliable insulation;

inaccessibility of live parts of equipment (enclosure of electrically damaging elements in a housing, conclusion of live parts in a housing).

5.6 Ecological safety

5.6.1 Analysis of the impact of the research object on the environment

The using of radio waves gives to industry great possibilities and finds a wide range of applications. The most known are communications. As energy of radio waves is dissipated with distance effect of irradiation by radio waves was thoroughly study by scientist. There are a series of standards and legal notes to limit power of radio waves sources due harmful effect on biological tissues.

The impact on hydrosphere, atmosphere and lithosphere is a question to debate because of a small number of investigations in this field. Main impact could be only from powerful sources like radiolocation stations.

5.6.2 Analysis of the environmental impact of the research process

Process of investigation itself in the thesis do not have essential effect on environment. One of hazardous waste is fluorescent lamps. Mercury in fluorescent lamps is a hazardous substance and its improper disposal greatly poisons the environment.

Outdated devices goes to an enterprise that has the right to process wastes. It is possible to isolate precious metals with a purity in the range of 99.95–99.99% from computer components. A closed production cycle consists of the following stages: primary sorting of equipment; the allocation of precious, ferrous and non-ferrous metals and other materials; melting; refining and processing of metals. Thus, there is an effective disposal of computer devices.

5.6.3 Justification of environmental protection measures

Pollution reduction is possible due to the improvement of devices that produces electricity, the use of more economical and efficient technologies, the use of new methods for generating electricity and the introduction of modern methods and methods for cleaning and neutralizing industrial waste. In addition, this problem should be solved by efficient and economical use of electricity by consumers themselves. This is the use of more economical devices, as well as efficient regimes of these devices. This also includes compliance with production discipline in the framework of the proper use of electricity.

Simple conclusion is that it is necessary to strive to reduce energy consumption, to develop and implement systems with low energy consumption. In modern computers, modes with reduced power consumption during long-term idle are widely used.

5.7 Safety in emergency

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

The fire is the most probable emergency in our life. Possible causes of fire:

- malfunction of current-carrying parts of installations;
- work with open electrical equipment;
- short circuits in the power supply;
- non-compliance with fire safety regulations;

presence of combustible components: documents, doors, tables, cable insulation, etc.

Activities on fire prevention are divided into: organizational, technical, operational and regime.

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

Organizational measures provide for correct operation of equipment, proper maintenance of buildings and territories, fire instruction for workers and employees, training of production personnel for fire safety rules, issuing instructions, posters, and the existence of an evacuation plan.

The technical measures include compliance with fire regulations, norms for the design of buildings, the installation of electrical wires and equipment, heating, ventilation, lighting, the correct placement of equipment.

The regime measures include the establishment of rules for the organization of work, and compliance with fire-fighting 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 (sealing equipment, control of the air, working and emergency ventilation);

- use in the construction and decoration of buildings of non-combustible or difficultly combustible materials;
- the correct operation of the equipment (proper inclusion of equipment in the electrical supply network, monitoring of heating equipment);
- correct maintenance of buildings and territories (exclusion of the source of ignition prevention of spontaneous combustion of substances, restriction of fire works);
- training of production personnel in fire safety rules;
- the publication of instructions, posters, the existence of an evacuation plan;
- compliance with fire regulations, norms in the design of buildings, in the organization of electrical wires and equipment, heating, ventilation, lighting;
- the correct placement of equipment;
- well-time preventive inspection, repair and testing of equipment.

In the case of an emergency, it is necessary to:

- inform the management (duty officer);
- call the Emergency Service or the Ministry of Emergency Situations - tel. 112;
- take measures to eliminate the accident in accordance with the instructions.

Conclusion

In the course of the work done, a device for bio-impedance spectrometry was developed.The main parts of the device are an impedance convector based on the AD5933 microcircuit, a Howland current source and a microcontroller.

Before starting work, the device was tested for operability using an equivalent cell circuit. The measurement results of the circuit coincide with the theoretical data, which indicates the accuracy of the measurements by the device. Researchers have shown that the device allows measuring the impedance in the frequency range from 10 Hz to 100 kHz.

To assess changes in the electrical properties of tissues after irradiation, measurements were made in a patient with breast cancer. Existing data show that a lower phase angle means a decrease in cell integrity or cell death, and that a higher phase angle implies the presence of a large number of intact cell membranes.

Measurement of the phase angle for diagnostic purposes has confirmed that this parameter has great prognostic value in various diseases.

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