



Co-funded by the  
Erasmus+ Programme  
of the European Union



**Innovative Multidisciplinary Curriculum in Artificial Implants for Bio-Engineering BSc/MSc Degrees**

## **WP1 BIOART Report**

### **Evaluation on Existing Curricula**

**P12 Vinnitsya National Technical University**

#### **Authors:**

**Oleksandr Hrushko, Prof., Doctor of Sciences, Prof. of Materials Strength and Applied Mechanics Department, Head of the Institute of Master, Postgraduate and Doctoral Degree Studies**

**Serhii Pavlov, Doctor of Sciences, Vice Rector on Scientific Works, Prof. of Biomedical Engineering Department**

**Serhii Tymchyk, PhD, Assoc. Prof. of Biomedical Engineering Department**

**Inna Vishtak, PhD, Assoc. Prof. Safety of Life and Pedagogy of Security Department**

**Serhii Veremiyenko**

**20.01.2018**

## 1. Current status of VNTU for training specialists in specialty 163 -biomedical engineering

In Vinnytsia National Technical University curricula of the specialties in medical direction (163 - biomedical engineering), approved by training programs for training bachelors and masters at the meeting of the Scientific Council of VNTU (Minutes No. 16 of June 22, 2017, No. 12 March, March 30, 2017) are aimed at training of specialists to meet the needs of enterprises, operating in the sphere of production and maintenance of specialized engineering systems, medical institutions in Ukraine to provide high-quality technical and information services. For the training of specialists in the field of 163 - Biomedical Engineering (Bachelor) and specialty 163 - Biomedical Engineering to the educational and qualification level "master" of the field of knowledge 16 - chemical and bioengineering VNTU has the necessary personnel, material and technical, information and educational support for training. According to the licensing conditions, the following materials have been prepared: the educational and qualification characteristics of the specialist; educational and professional training program for a specialist; curriculum, approved in the prescribed manner.

As a basic department for training specialists in medical specialties in VNTU, the department of biomedical engineering of VNTU is involved.

Table 1 - List of specializations of medical direction in VNTU.

Code and name of the field of knowledge	Code and name of specialties	Department	number of students		
			1 course	2 course	3 course
16 Chemical and bioengineering	163 Biomedical Engineering (Bachelor)	BME	6	3	6
16 Chemical and bioengineering	163 Biomedical Engineering (Master)	BME	18	10	

Curriculum of Bachelor's training in the field of training 163 - Biomedical engineering is developed in accordance with the requirements of the Ministry of Education and Science of Ukraine, approved by the Rector of the VNTU. The duration of training for full-time students is 3 years 10 months. The curriculum is designed in accordance with the requirements of the Bologna Process, it is constantly being improved and adapted to the needs of modern demand in the labor market. Curriculum for the preparation of a bachelor in the field of training 163 - Biomedical Engineering envisages 240 credits ECTS.

The curriculum for training bachelors includes the teaching of disciplines:

- regulatory part;
- variable part. In addition, in the variable part the cycle of educational disciplines is provided: at the choice of the University; free choice of students (from the cycle of educational disciplines of professional and practical training).

Three cycles of academic disciplines are supposed to be taught:

- humanitarian and socio-economic training;
- mathematical and natural-science training;
- professional and practical training.

Curriculum of master's training in specialty 163 - Biomedical engineering is developed in accordance with the requirements of the Ministry of Education and Science of Ukraine, approved by the rector of VNTU. The term of study for full-time students is 1 year 10 months. The curriculum for training of masters includes the teaching of disciplines:

- regulatory part,
- variable part.

Two cycles of academic disciplines are supposed to be taught:

- humanitarian and socio-economic training;
- professional and practical training.

In addition, in the variable part is supposed to contain the cycle of academic disciplines.

- at the choice of the University;
- free choice of students (from the cycle of educational disciplines of professional and practical training). To implement the free choice of the student, a higher education institution offers two blocks of disciplines of this plan.

The student's work at the discipline in the course of the semester consists of the lecture hours (lectures, practical classes, seminars, laboratory sessions, consultations), independent work, preparation and passing the control measures, which are covered by credits, established for academic disciplines.

### **a. Existing biomedical courses are offered as specialization ( B.Sc. Level).**

Specialization "Biomedical Engineering"

#### **1. Nanotechnologies in biomedical science** (total volume - 210 hours).

The purpose of the discipline - is to teach bachelors the fundamental and applied knowledge and skills in the study of the properties of the transmission of optical radiation through optical media and optical systems, and further consideration of these properties in the study of nanoelectronics for biomedicine.

**Equipment.** For better mastering these disciplines, the equipment to perform fluorescence analysis is needed to study the cornea lesions of the eye.

#### **2. Health information technologies and their software** (total volume - 240 hours).

The purpose of the discipline - is to teach bachelors knowledge and skills in building, operating, configuring software for medical information technologies, developing and configuring databases, knowledge bases for medical systems.

#### **3. Data bases control systems in medicine** (total volume - 150 hours).

The purpose of the discipline - is to teach bachelors knowledge and skills in building, setting up, maintaining databases, managing medical databases.

Specialization "Radio electronic devices"

**1. Maintenance support of physical rehabilitation systems** (total volume - 210 hours).

The purpose of the discipline - is to obtain knowledge and skills regarding the specific features of conducting physical rehabilitation measures, restoring the functional state of the human organism, constructing facilities for performing physical rehabilitation and restoration.

**2. Fundamentals of the technology and manufacture of medical devices and systems** (total volume - 240 hours).

The purpose of the discipline - is to obtain knowledge and skills in the development, construction, production of medical devices and systems.

**Equipment.** To enhance the practical orientation of the discipline, sensors and built-in computerized systems that are components of medical equipment are needed.

**3. Systems of biomedical information processing** (total volume - 150 hours).

The purpose of the discipline is to teach bachelors knowledge and skills in construction systems for registration, transformation and processing of diverse types of data and the formation of an acceptable conclusion..

**b Existing biomedical courses are offered as specialization (M.Sc Level.)**

Specialization "Biomedical Engineering"

**1. Computer and medical and technical support of biotechnical and medical devices and systems** (total volume - 120 hours).

The purpose of the discipline is to teach master's knowledge and skills in the field of science studies, organization, carrying out and implementation of scientific research. The high level of modern development of international scientific relations also requires increased attention to the study and professional knowledge of foreign language.

**Equipment.** To enhance practical orientation of the discipline, sensors and built-in computerized systems are needed, which are components of medical equipment; complex for the adjustment and maintenance of specialized implants..

**2. Technology of repair and maintenance of biotechnical and medical devices and systems** (total volume - 210 hours).

The purpose of the discipline - is to obtain knowledge and skills in repair, maintenance, adjustment of biotechnical systems and devices; main mechanisms of of interference and parasitic processes impact on the accuracy and reliability of the operation of the BTMDS; safety rules for the repair of biomedical equipment; troubleshooting algorithms in BTMDS; methods of commissioning and certification of BTMDS; features of construction of searching algorithms of malfunctions in BTMDS, constructed on the base of complex computer equipment .

Specialization "Medical Informatics"

1. **Methods of modeling in biotechnical and medical devices and systems** (total volume - 120 hours).

The purpose of the discipline - is to obtain knowledge and skills and to form the notion regarding the features of regulatory processes in living organisms, the features of applying the methods of automatic control theory to them, and obtaining practical skills in performing analysis and synthesis of models of various biotechnical and biomedical devices and systems

2. **Problem-oriented programming in biotechnical and medical devices and systems** (total volume - 210 hours).

The purpose of the discipline - is to obtain knowledge and skills of the main principles and methods of creating, maintaining and applying software for BTMDS taking into account the specific characteristics of the given direction.

## **c Existing full courses of biomedical courses - level B.Sc.**

### **i General courses.**

1. **Mathematic modeling in biomedical science** (total volume - 90 hours).

The purpose of the discipline - is to obtain knowledge and skills in analyzing the properties of biological systems, modeling the dynamics of populations, metabolic processes in the organism, stochastic processes, pharmacokinetics.

2. **Biochemistry** (total volume - 150 hours).

The purpose of the discipline - is to obtain knowledge and skills of chemical transformations and processes occurring in the human organism, as well as the mechanisms of the impact of biologically active substances on the vital activity of the organism.

**Equipment.** For better mastering of these disciplines, the necessary equipment in the form of a digital microscope and specialized chemical equipment is needed.

3. **Engineering and computer graphics** (total volume - 120 hours).

The purpose of the discipline - is to study the fundamentals of computer graphics packages operation, the processes of formation of graphic design documentation for the design of electronic equipment, as well as the fundamentals of CAD operation.

4. **Informatics** (total volume - 300 hours).

The purpose of the discipline - is to obtain knowledge of basic principles of computer facilities operation, gain knowledge of working with current versions of software, familiarity with the theoretical principles of the operation of electronic computers, familiarity with the process of creating software for PC-compatible personal computers, as well as acquiring skills in work with the Delphi programming environment (RadStudio), database management systems and programs for creating web-sites.

5. **Human anatomy and physiology** (total volume - 150 hours).

The purpose of the teaching of the discipline - is to study the patterns of the structure and functioning and development of the human body as a whole, its structure and functioning characteristics that ensure normal life activity

**Equipment.** For better mastering of these disciplines, the equipment for a 3D human model (phantom), equipment in the form of a computer and a virtual reality helmet, software –Human Video-Atlas for viewing models in a 3D view are needed

6. **Biomedical devices, instrumentation and complexes** (P.1 Laboratory analytical equipment, P.2 Diagnostic equipment, P.3 Medical equipment) (total volume - 420 hours).

7. **Fundamentals of the theory of bioengineering systems** (total volume - 120 hours).

The purpose of the teaching of the discipline is to study the general principles of describing, classifying, analyzing and synthesizing the biotechnical systems underlying the construction of medical electronic equipment; studying the construction, functioning and interaction of radio electronic medical systems for various purposes; mastering the basics of designing biotechnical systems.

8. **Introduction to profession** (total volume - 90 hours).

The purpose of teaching the discipline is to provide students with knowledge and skills in the history and current state of biomedical engineering; prospects and conditions for the development of the profession; general information about the human body and its function from a system approach; the main trends in the development of medical equipment and the relevant labor market.

9. **Metrology, standardization, certification** (total volume - 90 hours).

The purpose of teaching the discipline is to provide students with knowledge and skills from the certification of medical devices, the requirements of standardization and the control of metrological characteristics of medical devices.

10. **Electronic engineering** (P.1 Fundamentals of circuits theory and signals, P.2 Electronic devices, P.3 Analogue circuit engineering, P.4 Digital circuit engineering, P.5 Microprocessor engineering) (total volume - 660 hours).

The purpose of the discipline - is to form a theoretical basis and practical basis for studying the general principles of the construction and operation of electrical circuits, as well as apparatuses and devices that consist of them; definition of the concept of "signal" and the structure of signals as information carriers; studying methods for analyzing electronic circuits; acquiring the skills of effective use of computer facilities for the modeling and analysis of electrical circuits. Familiarization of students with the elemental base for building units of medical equipment, the principles of its operation and the main characteristics; obtaining knowledge of students about the features of circuit solutions of the main nodes of modern diagnostic and therapeutic electronic medical equipment.

**Equipment.** To increase the practical orientation of the discipline, sensors and built-in computerized systems, which are components of medical equipment are needed.

**11. Biophysics** (total volume - 180 hours).

The purpose of the discipline - is to obtain knowledge and skills in the physical and chemical fundamentals of human organism functioning, molecular physical and chemical laws that are the fundamental of human life and health.

**Equipment.** For mastering these disciplines, the equipment in the form of a refractometer, biological membranes are needed..

**12. Biomedical mechanics** (total volume - 150 hours).

The purpose of the discipline - is to create substitutes for tissues and organs for the development of methods for influencing processes in living organisms, for cognition of the human motor abilities, for protecting a person from harmful environmental influences during its operation under extreme conditions.

**Equipment** For practical mastering of the discipline, we need tools to control the mechanical characteristics of materials: installation of stretching, compression, bending of samples, etc. The software for designing and modeling of 3D objects is necessary.

**13. Measuring information converters and sensors for medical and engineering systems** (total volume - 150 hours).

The purpose of the discipline is to familiarize students with the structures of medical measuring instruments and systems that have their own characteristics in comparison with information-measuring systems, as well as with the means and methods of conducting measurements.

**Equipment.** To increase the practical orientation of the discipline, sensors and built-in computerized systems, which are components of medical equipment, are needed.

## **ii Specialization courses.**

### Specialization "Biomedical Engineering"

**1. System analysis and decision-making in medicine** (total volume - 150 hours).

The purpose of the discipline is to familiarize students with the basics of system analysis and build decision support systems in medical systems.

**2. Methods and processing means of biomedical signals, data and images** (total volume - 180 hours).

The purpose of the discipline is to familiarize students with the methods and means of processing and transformation of biosignals, medical data, images.

**3. System of computer-aided design for radioelectronic equipment** (total volume - 210 hours).

The tasks of the discipline are familiarizing the students with computer technologies for calculating, designing and modeling the operation of the nodes of medical equipment.

**4. Operation, repair and maintenance of medical equipment** (total volume - 210 hours).

The purpose of the discipline is to study the issues related to the operation and maintenance of medical equipment, taking into account the features of its use and application.

Specialization "Radio Electronic Devices"

**1. Modeling of biomedical processes and signals** (total volume - 150 hours).

The purpose of the discipline is to provide students with knowledge, skills regarding the features of modeling biosignals of living organisms, the features of applying the methods of automatic control theory to them, and obtaining practical skills in the synthesis of models of various biotechnical and biomedical devices and systems.

Equipment. To increase the quality of modeling, software development tools and simulation systems are needed.

**2. Fundamentals of biomedical equipment design** (total volume - 180 hours).

The purpose of the discipline is to provide students with the knowledge, skills of the processes of designing and producing electronic equipment; application of methods of automatic control in the design of biotechnical and biomedical devices and systems.

**3. Fundamentals of construction and application of bioengineering and medical systems** (total volume - 210 hours).

The purpose of the discipline is to study the physical foundations, the principle of action and the basis for the construction of medical equipment of various purposes, including measuring, diagnostic, physiotherapeutic.

**4. Telehealthcare systems** (total volume - 210 hours).

The purpose of the discipline is to acquire knowledge, skills, operation skills, settings, and functional parameters support for individual units of telehealthcare systems and systems in general.

**d. Existing biomedical courses of the complete curriculum - level M.Sc**

**i General courses**

**1. Modern information technologies in the field of chemical and bioengineering** (total volume - 120 hours).

The purpose of the discipline is the acquisition of knowledge and skills in the application of information technology in science and education in the field of chemical and bioengineering.



**2. Methodology and organization of scientific research** (total volume - 120 hours).

The purpose of discipline is to get acquainted with the methodology of scientific research, the basic principles and stages of its organization; obtaining skills on its application in practical activity; study of the current state of science and scientific activity in Ukraine and in the world; studying the systems and principles for the organization and management of scientific research at the regional, national and international levels.

**3. Processing of biomedical images and reconstruction of objects** (total volume - 150 hours).

The purpose of the discipline is to study the basic principles and methods of processing biomedical images, to acquire students' theoretical knowledge and practical skills in working with programs for processing digital and, in particular, biomedical images, acquaintance with the theoretical and practical aspects of reconstruction of biomedical images.

**Equipment.** For practical mastering of the discipline, tools for designing and modeling of 3D objects: CAD and SAE-systems are needed.

**4. Computer technologies in medicine** (total volume - 300 hours).

The purpose of the discipline is to study the principle of action, construction and fundamentals of circuit engineering computer equipment for use in medicine, as well as the design and management of medical databases and telemedical systems.

**5. Biotechnical systems of medical purpose** (total volume - 180 hours).

The purpose of the discipline is to study the general principles of describing, classifying, analyzing and synthesizing the biotechnical systems underlying the construction of medical electronic equipment; studying the construction, functioning and interaction of radio electronic medical systems for various purposes; mastering the basics of designing biotechnical systems.

**6. Medical equipment of special purpose** (total volume - 120 hours).

The purpose of the discipline is to study the fundamentals of technical means of medical introscopy, as well as the physical principles of instruments operation and the possibilities on this basis to more deeply master the physical interpretation of the results of research, to combine the medical and physical interpretation of diagnostic procedures.

## **2. Regional Labor Market Requirement Analysis**

### **a. Preliminary Work**

Modern medicine requires thorough technical support, mainly information technology in the organization of the treatment process, patient monitoring, computer diagnostics, therapy, rehabilitation, electronic systems to maintain vital organism functions, and the like. The quality and performance of specialized equipment and technologies in clinical settings today determines the level of medical care and increases the overall probability of rescuing patients. The introduction, maintenance and repair of complex electronic medical equipment of the world's leading manufacturers requires appropriate knowledge and skills, and the availability of practical experience. Such complex technical tasks can no longer be assigned to medical personnel, and only a biomedical engineering specialist is able to provide high-quality and reliable operation of modern electronic medical and biological systems.

Specialists in biomedical engineering combine technical knowledge and biomedical aspects of their application. The development of medical and biological equipment over the past decade is accompanied by an increase in the need for trained bioengineers in the industry as a whole and, in particular, in the Central and Western regions of Ukraine.

The training of specialists in biomedical engineering at the present stage requires the application of the latest scientific achievements, technological and methodological innovations in the teaching work. It is important to take into account the specifics of each of the applied branches, universal and coordinated teaching of technical, biological and medical aspects of instrument making.

### **b. Trends and requirements in the industry**

Providing a growing need for engineers with medical electronics, over the last quarter of a century in the universities of Ukraine, about two dozen specialized departments have been created. Their long scientific and pedagogical experience testifies that the specificity of the process of training a specialist in biomedical electronic equipment necessitates the separation of existing medical and technical specialties into the new direction "Biomedical Engineering".

Analysis of the current socio-economic state of the Central and Western regions of Ukraine made it possible to identify the following trends:

- there is an increase and improvement of the technical base of public medical institutions and institutions, requires an increase in the number of specialists in medical engineering;
- wide introduction of the newest expensive computer, hardware and hardware-software diagnostic and therapeutic complexes, complex laboratory equipment and medical devices requires the availability of qualified domestic specialists;
- the specific weight of the technical component in medicine increases and its importance grows, which requires perfect training of engineering personnel;

- there is a growing need for the development of comprehensive research in the field of fundamental biology and medicine, requires deep cooperation with technical scientists.

Especially significant demand for specialists in biomedical engineering exists at the enterprises of medical instrument making, in the field of application of industrial biotechnologies, in research and medical institutions, as well as in rehabilitation and rehabilitation of citizens' ability to work.

Preliminary study of the demand for specialists in biomedical engineering and experience in employment showed the relevance of such institutions and enterprises in the region:

- establishments of sanatorium-resort and restorative treatment (for example, sanatorium "Podillya", Khmilnik)
- Medtekhnika;
- Vinnitsa state experimental prosthetic and orthopedic enterprise;
- Regional dental clinic in Vinnitsa;
- Military Medical Clinical Center.

The Department of BMI maintains links with specialized state authorities, educational institutions, enterprises, organizations and institutions, in particular, the Kiev National Technical University of Ukraine "Kyiv Polytechnic Institute. Igor Sikorsky ", Kharkiv National Technical University" KhPI ", National University" Lviv Polytechnic ", Kharkov National University of Radio Electronics, National Aerospace University. Zhukovsky and many other leading universities and commercial research and production structures. Considerable attention is paid to cooperation with scientific research institutions, sanatoria and health resorts and medical institutions in Ukraine and other countries. There are working agreements with the sanatoriums of Vinnitsa region, OJSC Medtekhnika, Vinnytsia central regional hospital, Lutsk Biotechnical Institute, leading scientific institutions of Azerbaijan, Portuglia.

### **3. Prospects of Project Implementation**

#### **a. Involved Departments**

The development of the technical support of the biomedical industry is one of the priority tasks of the state on the way of introducing European standards of medical services to the population and the application of biotechnology. Therefore, specialists in the field of biomedical engineering should solve the following problems:

- design, support production, ensure operation, maintenance and repair of intelligent artificial implants;
- provide technical improvement and maintenance of basic medical technologies, including computer and telecommunications;
- to contribute to the creation and approbation of mathematical models of processes and objects of medical equipment, algorithms for solving typical problems.

Taking into account the above and previous internal analysis of VNTU's capacities, such departments and divisions of the university will be involved in the project:

BME - Biomedical Engineering Department (basic department of development and implementation of new curriculum). The department carries out training of specialists in 163 - biomedical engineering, which is producing biomedical engineering for a specialty. The BME department employs teachers with extensive experience in pedagogical, research and practical activities, which allows for high-quality training of specialists. The laboratories of the BME department are equipped with a modern material and technical base for conducting the educational process and research work. The laboratory of the department includes: a laboratory of biological and physiological management systems, a laboratory of medical and biological computer systems, a laboratory for functional diagnostics, a laboratory for the production of medical equipment, and computer classes.

MSAM - Materials Strength and Applied Mechanics Department (the department will develop and implement courses on the mechanical direction of bioengineering, testing of biomaterials, etc.). At the Department of Resistance of Materials, general training of specialists of various specialties and specializations is carried out. We teach fundamental disciplines of mechanics (applied mechanics, technical mechanics, mechanics, theoretical mechanics, resistance of materials). The department has specialized laboratories for mechanical testing and laboratory equipment for studying the basic laws of mechanics, the properties of construction materials for machine building and construction purposes. There is a powerful scientific school. To provide the training project, which is being developed, it is necessary to purchase test equipment (desktop universal test machine) by definition of mechanical characteristics, technological tests of the implant, software for imitation simulation of the implant by the finite element method (preferably LS-DYNA).

SLPS - Safety of Life and Pedagogy of Security Department (the department will develop and implement courses on the safety of using artificial implants). The department provides teaching of disciplines related to safety of vital functions, occupational safety and so on. The disciplines are oriented, among other things, to the introduction of innovative technologies of training on quality, conformity to standards and safety of technologies in production and medicine in the implementation of national health promotion programs, improving the quality of life, and the introduction of European quality standards. Laboratories of the department are equipped with stands for the study of safe working conditions.

MBTA - Machine-building Technology and Automation Department (the department will develop and implement courses of mechatronics in artificial implants, design and manufacture of artificial implants, etc.). The Department provides the study of computer-aided design (CAD), manufacturing (CAM) and life-cycle support of industrial products (PLM), as well as automated production systems based on CNC technologies, mechatronic modules and robotic complexes. The object of activity of specialists in the specialty "Applied Mechanics" is the design and manufacture of modern high-performance machines, mechatronic systems, instruments, equipment and installations for various purposes in all industries. The laboratories of the department are equipped with metal-cutting equipment with control systems of the firm "Siemens", educational hydraulic and electro-pneumatic stands of the firm "Festo". Powerful scientific school has been functioning at the Department.

InMPDS - the Institute of Magistracy, Postgraduate and Doctoral Studies (the Institute will develop and adapt a new curriculum for the training of Masters).

TTC is a technical translation center (the center will carry out a technical translation of the materials of the curriculum).

Also, other departments may be involved in the current need, in particular to expand and introduce specializations of the biomedical field.

### **b. Risk identification**

The risks associated with the implementation of the results and realization of the project should include:

- 1) changes in the Charter of VNTU, restructuring of the University;
  - 2) changes in the distribution of the state order for the training of specialists (the possibility of the absence of applicants)
  - 3) the absence in the staffing table of medical institutions of a full-time post "biomedical engineer";
  - 4) the turnover of scientific and pedagogical staff to be involved in the development and implementation of courses;
- other force majeure circumstances of insuperable force.