Biomedical Engineering BSc joint Programme.

2021-1-HU01-KA220-HED-000032251

Virtual Biomedical and STEM/STEAM Education - VIBE

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Biomedical Engineering BSc joint Programme

This document is for the curriculum of the Biomedical Engineering BSc joint degree program. The Biomedical Engineering BSc joint degree is a full-time two-year program. Participants are required to complete both years and all program requirements. Upon completion, students will be eligible to receive two Bachelor in Biomedical Engineering degrees in two European institutions.

General information:

- 8 semester training, with 7 semester of courses and 1 semester of project work.
- The first 3 semester are mainly covering health and engineering sciences.
- From 4-7 semester the students will take specialized courses.
- The minimum credits requirement is 210
  - Basic courses: 54 credit medical (M) + 66 credit engineering (E)
  - Specialty courses: 40 credit
  - Project and thesis work: 40 credit
  - Elective courses: 10 credit
- The elements of competence (knowledge, skills and attitudes) are defined for the training output, provided recommended and mandatory literature, and information on the fulfilment requirements.
- the weekly workload and credits are specified for each subject, which are summarised in a transparent table. In addition, the credit and lesson load per semester has been aligned with EU expectations.
- During the joint programme, students can complete a specialisation, defined by the partner institutions as 40 credits, and their project work, which is the basis for the thesis.
- With this structure, students spend the first 3 semesters at their gestor institution, after which they take courses at the partner institution for a minimum of 60 credits between 4 and 7 semesters.

I. **Basic courses: medical (M) and engineering (E) basics for all of the students irrespective of future specialization:**

- Anatomy (M)

  - Description: comprehensive understanding of the human body's complex structure and function. This subject provides future engineers with the essential knowledge to design and innovate medical devices, prosthetics, and healthcare solutions, bridging the

gap between biology and technology. By delving into anatomy, students gain a profound appreciation for the intimate relationship between form and function in the realm of biomedical engineering.

- Physiology (M)

○ Description: Physiology is a crucial component of biomedical engineering education, providing students with a deep understanding of how the human body functions at the cellular and systemic levels aiming to supply future engineers with the knowledge to develop cutting-edge medical devices, biomechanical solutions, and healthcare technologies, as it underpins their ability to design products that interact seamlessly with the human body.

- Biochemistry (M)
  - Description: Biochemistry offers students a profound insight into the molecular and chemical processes that govern life. This subject gives fundamental basics to develop innovative solutions, such as drug delivery systems and biomaterials, by understanding the intricacies of biological molecules and their interactions.

- Biophysics (M)

  - Description: Biophysics focuses on the application of physical principles to unravel biological phenomena. This subject equips students with the tools to analyze and model the intricate mechanical and electrical aspects of the human body, enabling them to design precision medical devices, imaging technologies, and diagnostics. By studying biophysics, students gain the expertise to develop solutions that optimize the interface between physics and biology for improved healthcare outcomes.

- Cell biology (M)

  - Description: Cell biology provides students with an in-depth understanding of the building blocks of life - cells. This subject equips future engineers with the knowledge to design and develop biomedical technologies, from cellular-based therapies to tissue engineering. By understanding cell biology, students gain insights into the intricate workings of the human body at the cellular level, fostering innovations that drive progress in healthcare and medical research.

- Medical imaging (M)

  - Description: Medical imaging is a core component of biomedical engineering education, focusing on the use of advanced technologies to visualize and analyze the human body for diagnostic and therapeutic purposes. This subject equips students with the skills to understand and improve imaging modalities, such as MRI, CT, and ultrasound, to advance healthcare diagnostics and patient care.

- Regulation and ethical aspects of biomedical field and device regulation (M)

  - Description: The study of regulation and ethical aspects in the field of biomedical engineering is a critical component of education, as it ensures that future engineers understand the legal and ethical framework that governs medical devices and technology nationally and internationally. This subject

equips students with the knowledge needed to navigate complex regulatory pathways, ensuring the safety and efficacy of healthcare innovations.

- Certification of medical products (M)
  - Description: Certification of medical products is a subject that focuses on the international regulatory processes and standards required to ensure the safety and effectiveness of

medical devices and pharmaceuticals. Students in this field learn how to navigate complex certification procedures, conduct quality assessments, and meet regulatory requirements, ensuring that medical products meet the highest standards of quality and can be safely used in healthcare settings.

- Mathematics (E)

○ Description: Mathematics is the foundational backbone of biomedical engineering education, providing students with the essential tools to model, analyze, and solve complex problems in healthcare and medical technology. This subject equips future engineers with the quantitative skills required to optimize medical device design and data analysis.

- Engineering calculations (E)

○ Description: The subject introduces the students to the quantitative skills necessary to design and analyze medical devices, systems, and processes. By studying engineering calculations, students acquire the proficiency to make

informed, data-driven decisions that drive innovation and advancements in biomedical engineering.

- Programming languages (E)

○ Description: The subject enables students to develop software and algorithms essential for medical device design, data analysis, and computational modeling. Students will gain knowledge and skills to create innovative solutions, integrate technology into healthcare, and advance medical research through coding and automation.

- Engineering Mechanics (E)

○ Description: Mechanics provides a strong foundation in the principles of forces, motion, and material behavior, enabling students to design and analyze medical devices, prosthetics, and biomechanical systems. The knowledge provided will aid students to address the mechanical challenges inherent in the healthcare field, ensuring the safety and efficacy of their innovations.

- Physics (E)

○ Description: The aim of courses in Physics is to provide an adequate exposure and develop insight about the basic principles of physics along with the possible applications. The acquaintance of basic physics principles would help engineers to understand the tools and techniques used in the industry and provide the necessary foundations for inculcating innovative approaches. This would create awareness about the vital role played by science and engineering in the development of new technologies. The courses would provide the necessary exposure to the practical aspects, which is an essential component for learning science.

- Biostatistics (E)

○ Description: The subject provides analytical tools to interpret and make informed decisions based on healthcare data, design experiments, conduct clinical trials, and evaluate the effectiveness of medical interventions, ensuring data -based decision-making.

- Basics of Electrical Engineering (E)

○ Description: Electronics is a subject that delves into the principles of electrical circuits, semiconductors, and electronic components, providing students with the knowledge and skills needed to design, analyze, and troubleshoot various electronic systems. The subject helps the students to gain the fundamental discipline in engineering and technology education, aiming to create innovative devices, enhance communication systems, and contribute to advancements in fields such as robotics, telecommunications, and consumer electronics.

- Semiconductor devices, sensors (E)

○ Description: Semiconductor devices and sensors in biomedical engineering explore the integration of cutting-edge electronic components and sensors for healthcare applications. This subject equips students with the expertise to develop advanced medical devices, diagnostic tools, and monitoring systems, harnessing the power of semiconductors to improve patient care and medical research.

- Signal processing (E)

○ Description: Signal processing in biomedical engineering is a critical discipline that focuses on the analysis and manipulation of data acquired from various sensors and medical instruments. This subject introduces essential tools to extract meaningful information from biological signals, supporting the development of advanced diagnostic and monitoring systems, and contributing to improved healthcare outcomes.

- Biomechanics (E)

○ Description: Biomechanics is the study of the mechanical aspects of living organisms, examining how forces and motion affect biological structures and systems. In this subject, students explore the interplay between physics and biology, gaining a deep understanding of how mechanics can be applied to design prosthetics, enhance sports performance, and improve medical treatments and develop supporting technology.

- Machine construction (E)

○ Description: Machine construction is a field that focuses on designing, building, and maintaining various mechanical systems and devices. It encompasses the knowledge and skills required to create efficient and reliable machinery, from intricate manufacturing equipment to robust machines helping the advancement of biomedical engineering and healthcare solutions.

- Biomaterials and implants (E)

- Description: Biomaterials and implants introduces different biomaterials and explores the development, selection, and application of materials used in medical devices and implants. Students will learn how to design and create biocompatible materials and implants, ensuring they are safe and effective for use within the human body, and driving innovations in healthcare, prosthetics, and medical technology.

- Robotics (E)

- Description: Robotics introduces students to the interdisciplinary field of the design, construction, operation and the main biomedical applications of robotic systems.

- Computer graphics (E)

- Description: Computer graphics is a field of study that explores the creation, manipulation, and rendering of visual images and animations using computer technology. It encompasses the development of software and algorithms to generate and display graphics for various biomedical applications.

- Engineering design and communication (E)

- Description: The subject emphasizes the principles and techniques of effectively conveying technical information and designs within the engineering field. The students will learn to create modern electric systems and to prepare clear and concise engineering documents, including drawings, reports, and presentations, which are essential for communicating ideas, project specifications, and design concepts in the biomedical field.

II.Specialization programs (80 credits) 3 semesters

- **Robotics, prosthetics and advanced – all courses include lectures and hands-on practice**

○ Biomedical Computing

▪ The subject combines principles of computer science and data analysis with applications in the biomedical field. It equips students with the

skills to develop and apply computational tools, algorithms, and software to solve complex problems in healthcare, ranging from medical imaging and data analysis to drug discovery and genomics, contributing to advancements in biomedical research and patient care.

○ Orthopedic Biomechanics and Mechanobiology

▪ This is a specialized subject within biomedical engineering that focuses on the mechanical behavior of the musculoskeletal system and its interaction with biological processes. Students will explore how forces and mechanical factors impact the development, function, and treatment of orthopedic conditions, making it an essential subject for advancing knowledge in bone and joint health, as well as the design of

orthopedic devices, such as prosthetics and orthotics in advanced therapies.

○ Medical Device Design and Placement

▪ This subject centers on the development, innovation, and practical implementation of medical devices within healthcare. Students will learn how to design devices, address regulatory considerations, and understand the clinical and ethical aspects of placing medical devices in healthcare settings, contributing to the advancement of healthcare

technology and improving patient care.

○ Robotic systems

▪ This subject delves into the intricate design, control, and application of advanced robotic systems that exhibit high levels of autonomy, intelligence, and adaptability. Students will study the development of robots capable of complex tasks, such as autonomous navigation, human-robot interaction, and multi-robot collaboration, fostering innovations with wide-reaching impacts in fields like specialized healthcare purposes.

○ Smart prosthetics

▪ Smart prosthetics focuses on the development of technologically advanced limb and body-part replacements which are integrated with sensors, microcontrollers,

and artificial intelligence to enhance functionality and responsiveness for patients. Students in this field learn how to design and build prosthetic devices that can help or mimic natural movements and provide improved mobility and quality of life

for individuals with limb loss or limb impairment.

- Rehabilitation

  - Rehabilitation is a multidisciplinary subject that addresses the methods and techniques used to help individuals recover and regain function after injuries, surgeries, or health conditions. Students in this field learn to assess and design personalized rehabilitation programs that may include physical therapy, occupational therapy, and adaptive technologies to improve patients' physical and functional well-being, playing a crucial role in the recovery and quality of life of those in need.

- Signal processing

  - The subject deals with the analysis, manipulation, and interpretation of data, particularly in the context of various types of signals, such as data gained from biologic systems. Students will learn to develop algorithms and techniques to extract meaningful information from signals,

enabling applications in image and sound processing, multisystem responses (eg. neuromuscular systems), and data analysis.

- Clinical movement analysis

  - Clinical movement analysis is a subject that focuses on the evaluation and quantification of human movement patterns to aid in diagnosis, treatment, and rehabilitation of musculoskeletal and neurological conditions. Students in this field learn how to use specialized tools and technology to assess natural and supported gait, posture, and overall

movement, contributing to the development of effective therapies and interventions for individuals with mobility issues.

- Stimulation technologies

  - The subject will introduce the development and application of electrical, magnetic, or chemical techniques to stimulate biological tissues and neural systems for therapeutic or research purposes. Students will learn how to design and implement various forms of stimulation, from deep brain stimulation for neurological disorders to electrical muscle stimulation for rehabilitation and combined systems, which play a critical role in advancing medical treatments and scientific

investigations.

- Medical device regulation and certification

- Medical device regulation is a subject that delves into the complex legal and regulatory framework governing the design, manufacturing, testing and marketing of medical devices. Students will learn the standards, compliance requirements, and quality assurance processes necessary to ensure the safety and effectiveness of medical devices, contributing to the development and oversight of healthcare technologies that adhere to stringent regulatory standards.

- **Advanced material science – all courses include lectures and hands-on practice**

○ Mechanical analysis of materials

▪ Mechanical analysis of materials is a subject that explores the principles and methods for studying the mechanical properties of various materials, including metals, polymers, ceramics, and composites. Students in this field learn to perform experiments and simulations to evaluate material strength, elasticity, and behavior under different

loads, contributing to the design and selection of materials for a wide range of biomedical engineering applications.

○ Biocompatibility

▪ The subject explores the interactions between materials and living organisms, ensuring that medical devices and implants are safe and effective for use within the human body. Students will learn about basic principles of biocompatibility and examine the biological responses to materials, study the design principles for biocompatible devices, and contribute to the development of healthcare solutions that minimize
adverse reactions and promote patient well-being.

○ Database construction

▪ The subject focuses on the design, development, and management of structured data gaining and storage systems, allowing for efficient data

retrieval, storage, and manipulation. Students will learn to create and maintain databases that serve various purposes, from healthcare and finance to e-commerce, enabling the effective organization and utilization of data for decision-making and operational purposes.

○ Biomaterials and implants

▪ Biomaterials and implants is a subject that explores the development, selection, and application of materials used in medical devices, prosthetics, and implants within the healthcare field. Students will study the properties and biocompatibility of materials, as well as the

design and manufacturing processes for implants and devices, contributing to the advancement of medical technology and improving the quality of life for patients.

○ Additive manufacturing in biomedical engineering

▪ The subject focuses on the principles, techniques, and applications of 3D printing and other additive processes to create physical objects layer by layer. Students

are introduced to how to design, optimize, and produce complex structures and components, contributing to advancements in healthcare and manufacturing through innovative

and cost-effective manufacturing methods.

- Mechatronics

  - Mechatronic subject introduces a multidisciplinary field that combines principles of mechanical engineering, electronics, and computer science to design and create intelligent and interconnected systems. Students in mechatronics study how to develop automated and smart devices, ranging from robotics and automated manufacturing systems to advanced consumer products, integrating hardware and software for enhanced functionality and control.

- Medical device regulation and certification

  - Medical device regulation is a subject that delves into the complex legal and regulatory framework governing the design, manufacturing, testing and marketing of medical devices. Students will learn the standards, compliance requirements, and quality assurance processes necessary to ensure the safety and effectiveness of medical devices, contributing to the development and oversight of healthcare technologies that adhere to stringent regulatory standards.

- Materials mechanics

  - The subject explores the behavior of materials under various mechanical forces and conditions, providing insights into their strength, deformation, and fracture characteristics. Students will study how different materials, including metals, polymers, and composites,

respond to mechanical loads, facilitating advancements in materials science, structural engineering, and the design of biomedical devices.

- Medical Device Design and Placement

  - This subject centers on the development, innovation, and practical implementation of medical devices within healthcare. Students will learn how to design devices, address regulatory considerations, and understand the clinical and ethical aspects of placing medical devices in healthcare settings, contributing to the advancement of healthcare technology and improving patient care.

- **Medical Image analysis – all courses include lectures and hands-on practice**

- Database construction

  - The subject focuses on the design, development, and management of structured data gaining and storage systems, allowing for efficient data retrieval, storage, and manipulation. Students will learn to create and maintain databases that serve various

purposes, from healthcare and finance to e-commerce, enabling the effective organization and utilization of data for decision-making and operational purposes.

- Complex medical imaging

  - Complex medical imaging is a specialized subject within the field of biomedical engineering that explores advanced imaging modalities and techniques for the detailed visualization and analysis of anatomical and physiological structures. Students will learn to work and analyse with MRI, CT scans, and molecular imaging, enabling them to contribute to the development of highly detailed medical images for accurate

diagnoses and improved healthcare outcomes by implementing these systems to complex structure.

- Basics of artificial intelligence

  - The basics of artificial intelligence provides an introduction to the fundamental principles, algorithms, and techniques that underpin the development of intelligent computer systems. Students explore concepts like machine learning, neural networks, and natural language processing, equipping them with the foundational knowledge necessary to design AI-driven applications and solve complex problems
across a wide range of domains in healthcare.

- Virtual reality and modeling

  - Virtual reality and modeling is a subject that combines the principles of computer modeling with the creation of immersive virtual environments, enabling students to simulate and interact with digital representations of real or imagined scenarios. Students learn how to design, develop, and optimize virtual reality models and experiences

for applications spanning in healthcare, gaming, and training.

- Algorithms and data structures

  - The subject explores the fundamental building blocks of computer science, focusing on the design, analysis, and optimization of efficient algorithms and data storage methods. Students will learn to create and implement algorithms for tasks such as searching, sorting, and graph traversal, as well as to choose appropriate data structures to solve complex computational problems in various domains, including

software development, artificial intelligence, and data analysis.

- Applied imaging system

  - Applied imaging systems is a subject that focuses on the practical aspects of capturing, processing, and analyzing visual data using a variety of imaging technologies.

Students will learn to work with image acquisition equipment, image processing software, and computer

.

vision techniques, enabling them to address real-world challenges in fields such as medical imaging, remote sensing, and computer graphics in complex systems.

- Medical device regulation and certification

  - Medical device regulation is a subject that delves into the complex legal and regulatory framework governing the design, manufacturing, testing and marketing of medical devices. Students will learn the standards, compliance requirements, and quality assurance processes necessary to ensure the safety and effectiveness of medical devices, contributing to the development and oversight of healthcare technologies that adhere to stringent regulatory standards.

III. **Elective courses** – available during specialization year

- English language

  - The subject will provide advanced knowledge of literature, writing, and communication skills in English to master communication and scientific

knowledge.

- Introduction to publishing scientific data

  - The subject introduces the essential knowledge and skills required to effectively communicate and disseminate scientific research findings based on international standards. Students will learn and practice about the principles of academic writing, data presentation, and the publishing process, enabling them to contribute to the scientific

community by sharing their research through internationally recognized journals and publications.

- Bionics

  - Bionics is an interdisciplinary subject that explores the integration of biology and technology, aiming to understand and replicate natural processes and systems. Students will learn the basic principles to design and develop artificial organs, prosthetics, and devices inspired by biological principles, contributing to innovations in healthcare,

robotics, and human-machine interfaces.

- Simulation technologies and appliances

- The subject focuses on the utilization of computer-based models and hardware to create virtual environments for training, testing, and analysis across various fields, including healthcare, aviation, medical training and engineering. Students will learn to design, implement, and

optimize simulation systems, enhancing their ability to solve complex real-world problems, assess scenarios, and improve decision-making processes through the application of virtual technologies.

- Design of graphical user interface

- The subject of is centered around the creation of intuitive and user-friendly interfaces for software applications. Students learn how to design visually appealing and functional interfaces that enhance the user experience, making it easier for individuals to interact with

computer programs and systems, and improving the accessibility and efficiency of software applications.

- Artificial organs

- Artificial organs as a subject delve into the development and engineering of synthetic replacements for human organs and systems. Students in this field study the design, materials, and technologies required to create functional artificial organs, contributing to advancements in the field of medical science for modeling, drug therapies or improving the quality of life for individuals in need of organ transplants.

IV. Intership

- The students have to spend a 3 month practice in a Department or Company and gain applied knowledge in a freely chosen project

V. KNOWLEDGE OF THE BIOMEDICAL ENGINEER

K1 Knowledge of the scientific (mainly functional anatomy, systems biology, mathematics, physics, biophysics, biomechanics, biochemistry, molecular biology) and system and mechanical theory and practice relevant to the profession of biomedical engineering.

K2 Knowledge of the main modules of instrumentation required for biomedical measurements and therapeutic treatments and the principles of their diagnostic and therapeutic applications.

K3 Knowledge of the tools and methods of computer modelling and simulation relevant to the field of biomedical engineering.

K4 Knowledge of tools and methods for mathematical modelling and computer simulation of engineering and biological systems.

K5 Has basic communication, management, organisational and engineering skills.

K6 Has basic knowledge of quality assurance.

K7 Basic electrical safety knowledge of electronic devices used in healthcare.

K8 Has knowledge of organisational tools and methods related to management and the legislation required for professional practice.

K9 Knowledge of measurement techniques and measurement theory related to the field of biomedical engineering.

K10 Knowledge of information and communication technologies related to the field of biomedical engineering, use of relevant international literature resources on the Internet and other modern databases.

VI. SKILLS OF THE BIOMEDICAL ENGINEER

S1 Ability to apply scientific and engineering knowledge to process, organise, analyse and draw conclusions from information collected in the operation of systems and processes used in healthcare.

S2 Ability to model and characterise the functional structure of the human body and physiological processes and regulation.

S3 Ability to contribute original ideas to the knowledge base of biomedical engineering.

S4 Ability to apply integrated knowledge of healthcare equipment and processes and related electronics and informatics.

S5 Ability to plan and manage the use of technological, economic, environmental and human resources in a complex way.

S6 Ability to apply and develop procedures, models and information technologies used in the design, organisation and operation of systems and processes in health care.

S7 Ability to perform quality assurance, metrology and process control tasks in healthcare systems, technologies and processes.

VII. ATTITUDES OF THE BIOMEDICAL ENGINEER

A1 Working towards safety, sustainability and energy efficiency.

A2 Committed to health and safety culture and health improvement.

A3 Tends to work in a complex approach based on a systems and process-oriented thinking.

A4 In his/her work, he/she explores the possibility of setting and pursuing research, development and innovation objectives.

A5 Is open to continuing professional development for self-learning and self-development.

A6 Is committed to high standards of quality work and strives to communicate this approach to colleagues.

The total for a study plan and the skills, knowledge and attitudes can be seen in the attached sheet.