

**Final state examination thematic areas within the CEMACUBE - Common European Master's  
Course in Biomedical Engineering for biomedical master's degree program  
N3921 "Biomedical and Clinical Technology"  
at Czech Technical University in Prague - Faculty of Biomedical Engineering**

(joint study program of the 6 European universities included in the Erasmus Mundus program, double degree)

According to Article 7, paragraph 3 of the Dean's directive for the implementation of bachelor and master degree study programs at the Czech Technical University in Prague - Faculty of Biomedical Engineering Dean sets based on proposal by the head of the Department of Biomedical Technology thematic areas listed below.

Topics are designed in accordance with the valid accreditation approved by Ministry of Education, Youth and Sports on the 29th February 2012 Ref. MSMT/6894/2012-M3.

Topics are designed as the minimum required knowledge (theoretical and practical), which are necessary for successful graduate in practice. At the end of the thematic areas the names of the mandatory courses are summarized for better orientation of students. On the basis of paragraph 3 of Article 7 of the above mentioned Dean's Directive Thematic areas I. and II. are mandatory for the students. During the final state examination student gets assigned min. 2 questions from each thematic area. There are also allowed issues that are directly related to the theme of Master's project (thesis) or to the curriculum of student's CEMACUBE subjects. Questions enter the committee members, or a member of the committee determined by the chairman. Answers to questions should follow immediately after entering and without a written preparation.

**Thematic area I. – Fundamentals of Biomedical Engineering (mandatory** - based on the subjects and competences after year 1)

Biomaterials, biocompatibility. The mechanical characteristics of bones, tendons, ligaments, muscles and cartilage. Joints, hip and knee joint - total replacement. Mechanics of walking. Mechanics of the lower extremity. Mechanics hand grip strength. Intelligent prosthesis. Biomechanics of the heart and vascular system. Biomechanics of respiration.

Definition of diagnostic and therapeutic medical devices. Apparatus for blood pressure measurement. Measurement of blood oxygen saturation (pulse oximetry). Electrocardiographs. Electroencephalography. Monitor of vital signs.

How to apply for a grant project. Types of grant projects. Stages of proposal of the project. Specific requirements of projects. Documentation of the projects. Management, ordering and coordination of the project. Curriculum vitae. Planning and controlling of project realization. Presentation of the project. Team management in project. Sample application.

Overview of imaging systems, the relationship to the electromagnetic spectrum. Transfer properties of imaging systems (PSF, OTF, MTF). Principles of x-ray imaging, computed tomography. Principle of ultrasound imaging systems. Doppler systems.

Description of the procedure concerning the basic clinical examination of the patient. The manner and method of monitoring the health status of the patient.

Research project – structure, preparation, planning, scheduling, and controlling. Research paper – structure, preparation. Information sources.

Prerequisites (relevant subjects):

*Anatomy and physiology I., Biomechanics and Biomaterials, Fundamentals of Pathophysiology & Diagnostic Methods, Imaging Systems, Medical Devices & Equipment I, Project Proposal and Management, Work with Information Sources and Research Methodology.*

**Thematic area II. - Selected topics from the Biomedical Engineering (mandatory** - based on the subjects and competences after year 1)

Overview of the biosignals. Methods of biosignal sensing and fundamental parameters needed for the diagnosis of biosignals. Signals of the heart, brain, muscles and nervous system. Methods and algorithms for processing and evaluation of the most important biological (especially electrophysiological) signals, preprocessing, filtering, analysis in the time and frequency domain. Display of results, topographic mapping.

Pneumometry (spirometer, pneumotachograph, body composition). Medical devices for audiology, ophthalmology, optometry. Dilution methods. Electrical safety.

Technical principles of nuclear medicine: SPECT, PET. Overview and basic principle of reconstruction methods for tomographic imaging modalities. Principles of magnetic resonance imaging.

Structure and function of nucleic acids DNA and RNA. Replication, transcription, translation. Protein synthesis, prokaryotic and eukaryotic gene expression. Reproduction of cells, cell cycle, cell division. Gene manipulation.

Structure and function of proteins. Enzymes. Biochemistry of hormones. Metabolism of carbohydrates, lipids and lipoproteins, amino acids and proteins. Biochemistry of the digestive tract, pancreas and liver biochemistry. Biochemistry of kidneys. Biochemistry of muscle, bone. Biochemistry of the nervous system. Biochemistry and blood clotting process. The metabolism of body fluids and ions, acid-base balance.

Overview of the transport processes (Thermodynamics - equilibrium thermodynamics, total chemical potential, activities, barriers, fluxes, Fick's laws Equilibria across membranes, Nernst and Donnan-Gibbs, passive transport: free and facilitated diffusion, electro-diffusion, osmotic pressure, active transport, The Cell - structure, organization and energetics of an animal cell, Channels, carriers and pumps - classification, molecular structure, genetic manipulation, Neural signaling - neuron and the electrophysiological techniques, resting and activated membrane potential, Genesis of mechanical force - structure, regulation and functions of muscle proteins, cardiac contraction, blood pressure and circulation, capillary transports, Transcellular transports - organization of epithelial cell layers, pathways across leaky and tight epithelia, Gas transports - partial pressure, overview of the gas transport processes, gas exchanges in the lung and in the tissues, gas transport in the blood.

Prerequisites (relevant subjects): *Anatomy and physiology II., Biochemistry, Biological Signals, Biotransport, Imaging Systems, Medical Devices & Equipment I, Fundamentals of Molecular Biology.*

Supplement:

### **Competences after year 1**

*Students have basic knowledge of:*

- a. Anatomy of the musculoskeletal, circulatory, digestive, respiratory, excretory, endocrine and nervous systems and general knowledge of tissues
- b. Physiology of the muscular, circulatory, digestive, respiratory, sensory and nervous system
- c. General (patho)physiologic mechanisms (inflammation, infection, immunology, repair)

- d. Principles of biochemistry and cell biology
- e. Bio-instrumentation; overview of diagnostic instruments, their possibilities, limitations, physical principles, the phenomena they measure, the relation with the required information
- f. Medical imaging in terms of an overview of present equipment for diagnostics, their possibilities and limitations, their physical principles, the phenomena they measure.
- g. Biochemistry in terms of cell compartments; biological macromolecules; enzyme mechanisms; structure and function of membranes, antibodies, carbohydrates, lipids and proteins

*Students have advanced knowledge of:*

- h. Biomaterials in terms of an overview of potential materials, their properties, applications and limitations, in terms of biocompatibility and failure mechanisms.
- i. Signal analysis, system dynamics and computational mathematics
- j. Biomechanics in terms of statics, mechanics of materials (strength, stiffness, stress, deformation), dynamics (kinematics, kinetics, including gait analysis).
- k. Biotransport in terms of heat transport, mass transport, biofluid mechanics.
- l. Design/development; methodology, risk analysis, project management, market survey.
- m. Ethics, including regulatory affairs, social implications.
- n. Practical training in a European industry and hospitals, entrepreneurship as part of their professional development, IP.

*Student skills: students are able to:*

- o. apply knowledge and understanding in designing new/improved diagnostic instruments
- p. apply knowledge and understanding in designing new or improved therapy devices.
- q. make judgments, integrating medical, cultural, social and ethical insights into her/his work
- r. communicate in English having very good command of written and spoken language.
- s. communicate in one other language on a basic level, being the language of a host country.
- t. co-operate with other biomedical engineers and with medical experts.
- u. co-operate with international colleagues.
- v. reason soundly and to critically reflect on their own and others work.

### **Competences after year 2**

- a. Students have advanced knowledge of a particular field in Biomedical Engineering (one of the specializations, offered by the consortium).
- b. Students are able to apply and integrate knowledge of that particular field.
- c. Students are able to perform a research or design project by integrating all acquired knowledge and skills, and to show appropriate behavior given the professional context.
- d. Students are able to present their work in English both in writing and orally, and respond adequately to criticism.

Kladno, 21<sup>st</sup> December 2020

prof. MUDr. Jozef Rosina, Ph.D., MBA  
Dean of the Faculty

prof. Ing. Peter Kneppo, DrSc., dr. h. c.  
Head of the Department of Biomedical Technology