Topics for the Final state examination (FSE)
in the master's study specialization "Biomedical Engineering"
within the master's degree program N3921 "Biomedical and Clinical Technology"

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 is mandatory for the student mentioned areas I. Thematic area II. depends on the specialization. During the final state examination student gets assigned at least 2 questions from each thematic area. There are also allowed issues that are directly related to the theme of the Master´s project (thesis). Questions enter committee members, or a member of the committee determined by the chairman. Answers to the questions should follow immediately after their entering and without a written preparation.

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

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

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 imaging systems, the relationship to the electromagnetic spectrum. Transfer properties of imaging systems (PSF, OTF, MTF). TV imaging systems. Fundamentals of scanning and digitization (microscopic imaging systems, TV systems, HW + SW). Infrared imaging systems in medicine (thermal). Imaging in nuclear medicine (Anger camera). PET, SPECT. MRI. CT. Ultrasound imaging systems. Doppler systems.

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.

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

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.

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.

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.

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

Prerequisites (relevant subjects):
Anatomy and physiology I., II., Project Proposal and Management, Biochemistry, Imaging Systems, Fundamentals of Molecular Biology, Medical Devices & Equipment, Biomechanics and Biomaterials, Ethics in Biomedical Engineering, Work with Information Sources and Research Methodology, Biological Signals, Biotransport, Fundamentals of Pathophysiology & Diagnostic Methods

Thematic area II. - Selected topics from the Biomedical Engineering (based on the subjects and competences after year 2)

Prague**, specialisation **Medical Instrumentation

Electromagnetic Field in Medicine
Medical Devices & Equipment II
Design & Construction of Medical Devices/ Practical Exercises
Clinical Laboratory Instrumentation
Equipment for Anaesthesiology and Resuscitation
Laser Applications in Biomedicine

Interactions of electromagnetic field with matter. Biological effects of electromagnetic field, safety limits. Hyperthermia, principles and technical equipment. Hyperthermia applicators. Treatment planning. Hyperthermia thermometry. Microwave non-invasive thermometry.

Lung ventilators. Devices for electrosurgery. Pacemakers. Defibrillators. Extracorporal membrane oxygenation. Hemodialysis. Drug infusion pumps. Cochlear implants. Electro-therapy, Magneto-therapy.

Biopotential amplifiers, parameters and properties (frequency bandwidth, dynamic range). CMRR - Common Mode Rejection Ratio. Galvanic isolation, filtration of biosignals,S/H – sample and hold circuits, A/D and D/A converters. LabView system support.

Principles of the optical absorption, spectrometry, polarography, chromatography, electrophoresis, isotachophoresis, mass spectroscopy, atomic absorption spectrometry and osmometry. Centrifuges a ultracentrifuges, laminar boxes, conductometers, pH meters. PCR and DNA analyzers.

Specific requirements for equipment at intensive care units (ICU) and departments of anaesthesia and critical care medicine (ACCM). Blood gases, their measurement and interpretation. Principles and adverse effects of mechanical lung ventilation. Conventional and unconventional lung ventilation, corresponding ventilators. Equipment for anaesthesia. Anaesthetic vaporisers, their thermodynamic principles. Humidification of ventilatory gases. Equipment for monitoring and support of blood circulation. Monitors of vital signs.

Interaction of radiation with tissue, overview and characteristics of lasers. Lasers in various medical disciplines - application of laser radiation in ophthalmology, dermatology, dentistry, urology, cardiology, angioplasty, neurosurgery, orthopedics, gastroenterology, otorhinolaryngology, and photodynamic therapy. Laser safety.

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 judgements, 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
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 behaviour 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, 20th December 2021

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Dean of the Faculty

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