JAGIELLONIAN UNIVERSITY
MEDICAL COLLEGE

Biophysical fundamentals of medical technologies (with 30 hours of radiology)

Educational subject description sheet

Basic information

Department Faculty of Medicine	**Didactic cycle** 2016/17
Field of study Medical Program	**Realization year** 2017/18
Study level long-cycle master's degree program	**Lecture languages** English
Study form full-time	**Block** obligatory for passing in the course of studies
Education profile general academic	**Mandatory** obligatory
Disciplines Medical science	**Examination** examination
Subject related to scientific research Yes	**Standard group** B. Scientific basics of medicine

Subject coordinator	Eugeniusz Rokita
Lecturer	Eugeniusz Rokita, Bartosz Lisowski, Tomasz Rok, Grzegorz Tatoń, Karolina Wójcik-Piotrowicz, Dorota Zalitacz

Period Semester 4	**Examination** examination **Activities and hours** seminar: 12, laboratory: 36	**Number of ECTS points** 3.0

Goals

C1	To familiarize students with the laws and concepts in biophysics used to describe processes taking place in the human body, in particular with: (1) the basics of thermodynamics (solubility, diffusion, osmotic pressure, Donnan equilibrium), (2) biophysical description of cell, tissue and organ functioning and physiological processes in the human body, (3) laws of physics describing fluid flow and functioning of the vascular and respiratory systems, (4) basic laws describing electrical and magnetic phenomena in the human body (resting and action potential of the cell membrane, electrical properties of tissues, effects of electric current flow in the body, safety limits for current/voltage values, pacemaker, defibrillator.
C2	To familiarize students with the effects of physical factors such as temperature, gravity, pressure, acceleration, electromagnetic field and ionizing radiation on the human body, in particular with: (1) the sources of electromagnetic radiation and radiation properties depending on the source type, (2) influence of electromagnetic radiation from various ranges on living organism and its application in diagnostics and therapy, (3) the phenomenon of radioactive decay and various types of ionizing radiation, interaction of ionizing radiation with living matter, (4) risk assessment methods of influence of various physical factors on the human body, (5) dose harmfulness of non-ionizing/ionizing radiation and other physical factors acting on the human body, radiation protection.
C3	To familiarize students with the basics of physical methods used in diagnostics and therapy, in particular with: (1) analysis of biophysical phenomena and processes occurring in therapy and diagnostics, (2) physical background of non-invasive imaging methods, (3) physical description of selected therapeutic techniques e.g. ultrasounds and various types of electromagnetic radiation in a wide range of energies.
C4	To familiarize students with the use of simple measuring instruments, accuracy of measurements and planning experiments to determine the physical parameters of the object, in particular with: (1) operation of selected diagnostic and therapeutic measuring instruments (e.g. multimeter, ECG apparatus, laser, ultrasound apparatus, spirometer, magnetotherapy device, dialyzer, apparatus for electrodiagnostics, X-ray tube, radiometer), (2) using dedicated software supporting or controlling the operation of these devices and assess the accuracy of the performed measurements, (3) using databases, including online ones, and searching for the needed information with the use of available tools, (4) performing a biophysical experiment and analyzing measurement results with the use of statistical programs, spreadsheets and graphic programs.

Subject's learning outcomes

Code	Outcomes in terms of	Effects	Examination methods
Knowledge – Student knows and understands:			
W1	methods of diagnostic and therapeutic procedures appropriate for specific disease states	O.W3	oral answer, assignment report
W2	methods of conducting scientific research	O.W5	assignment report
W3	water and electrolyte management in biological systems	B.W1	assignment report
W4	terms: solubility, osmotic pressure, isotonia, colloidal solutions and Gibbs-Donnan equilibrium	B.W3	assignment report
W5	physical laws describing fluid flow and factors affecting vascular resistance to blood flow	B.W5	assignment report
W6	natural and artificial sources of ionising radiation and their interaction with matter	B.W6	oral answer, assignment report
W7	physicochemical and molecular basis of sensory organs activity	B.W7	assignment report
W8	the physical basis of non-invasive imaging methods	B.W8	oral answer, assignment report
W9	physical fundamentals of selected therapeutic techniques, including ultrasound and irradiation	B.W9	oral answer, assignment report

W10	basics of induction and transmission in the nervous system and higher nervous actions as well as physiology of striated and smooth muscles and blood functions	B.W20	assignment report
W11	activity and mechanisms of regulation of all organs and systems of the human body, including the cardiovascular system, respiratory system, digestive system, urinary tract and skin layers, and the interrelations existing between them	B.W21	assignment report
W12	the relationship between factors disturbing the balance of biological processes and physiological and pathophysiological changes	B.W25	oral answer, assignment report
W13	basic methods of statistical analysis used in population and diagnostic studies	B.W27	assignment report
W14	principles of conducting scientific, observational and experimental studies and in vitro studies for the development of medicine	B.W29	assignment report
W15	basic laws describing electrical and magnetic phenomena in the body	B.W30	oral answer, assignment report
W16	basic laws of mechanics referring to the skeletal and muscular system	B.W31	assignment report
W17	rules of using materials published on the Internet (copyright, quoting law, methods of obtaining free materials)	B.W37	oral answer, assignment report
Skills – Student can:			
U1	plan the diagnostic procedure and interpret its results	O.U3	assignment report
U2	use knowledge of the laws of physics to explain the effects of external factors such as temperature, acceleration, pressure, electromagnetic field and ionising radiation on the body and its elements	B.U1	oral answer, assignment report
U3	assess the harmfulness of the dose of ionising radiation and comply with the principles of radiological protection	B.U2	assignment report
U4	predict the direction of biochemical processes depending on the energetic state of cells	B.U6	oral answer, assignment report
U5	operate simple measuring instruments and evaluate the accuracy of measurements made	B.U9	assignment report
U6	use databases, including online databases, and search for the necessary information using the available tools	B.U10	assignment report
U7	select appropriate statistical tests, conduct basic statistical analyses, use appropriate methods of presenting results, interpret the results of meta-analyses and analyze the probability of survival	B.U11	assignment report
U8	plan and perform simple scientific research and interpret its results and draw conclusions	B.U13	assignment report
U9	indicate the relationship between factors disturbing the balance of biological processes and physiological and pathophysiological changes	B.U14	assignment report
U10	identify sources of electrical signals in the body	B.U15	assignment report
U11	use on-line photo, audio and video libraries	B.U21	assignment report

U12	provide expert knowledge through simple IT techniques of knowledge representation such as a block diagram or a rule database	B.U28	assignment report
U13	use lecture platforms	B.U30	oral answer, assignment report
Social competences – Student is ready to:			
K1	perceive and recognize own limitations and self-assessing educational deficits and needs	O.K5	assignment report
K2	use objective sources of information	O.K7	oral answer, assignment report
K3	formulate conclusions from own measurements or observations	O.K8	assignment report
K4	implement the principles of professional camaraderie and cooperation in a team of specialists, including representatives of other medical professions, also in a multicultural and multinational environment	O.K9	assignment report

Calculation of ECTS points

Activity form	**Activity hours***
lecture	6
seminar	6
laboratory	36
preparation for classes	12
preparation for classes	10
preparation for examination	19
participation in examination	1
Student workload	**Hours** 90
Workload involving teacher	**Hours** 48
Practical workload	**Hours** 36

* hour means 45 minutes

Study content

No.	**Course content**	**Subject's learning outcomes**	**Activities**

1.	Structure and states of matter - atomic nucleus, atom, molecule, gases (partial pressure, Dalton's law, air composition, vapors, liquids (surface tension, viscosity), solids (bone and tooth structure), phase transitions (ebullism), gas solubility in liquids (Henry's law, aeroembolism, caisson disease, oxygen intoxication, nitrogen narcosis). Biophysical description of biological systems, the living organism as a thermodynamic system, mechanisms of heat transport, heat loss of the body, the body's heat balance, basal metabolic rate, work of the heart, lungs and kidneys, hyperthermia, hypothermia and cryotherapy, mechanisms of membrane transport, diffusion phenomenon, Fick's law, osmosis, van't Hoff's law, osmotic pressure, role of the osmotic pressure in transport through the wall of capillary vessel.	W1, W12, W3, W4, U1, U13, U4, U9, K2	seminar, lecture
2.	Mechanical properties of biological systems, gravity, overloads, traffic accidents, balance and deformation of solids, Hooke's law, mechanical properties of bones. Fluid mechanics, hydrostatics, the effect of hydrostatic pressure on circulatory and respiratory systems functioning, speed distribution of blood in vessel, laminar and turbulent flow, volumetric flow, vascular resistance, pulse wave, description of cardiovascular and respiratory systems functioning based on fluid mechanics, blood pressure measurements.	W1, W11, W16, W5, U1, U13, K2	seminar, lecture
3.	Electrical and magnetic properties of the biological substances, electrical conductivity of tissues and organs, electric model of tissue, bioimpedance measurements, Hoorweg-Weiss curve, electrodiagnostics and electrotherapy, the effect of electric current flow on the human body, electric shock, pacemaker and defibrillator, magnetic fields, diamagnetic and paramagnetic materials, application of magnetic fields in medicine.	W1, W10, W15, W7, U1, U10, U13, U9, K2	seminar, lecture
4.	Types and sources of electromagnetic radiation, radio waves and microwaves, antennas, infrared radiation, visible light, photodynamic reactions, ultraviolet, physical background and properties of laser radiation, lasers, X-ray tube and its parameters, properties of X-ray radiation used in medicine, particle accelerators used in medicine. Influence of non-ionizing radiation on biological systems, application of electromagnetic radiation in the range of UV/VIS/IR in medicine, lasers in medicine, therapeutic application of electromagnetic fields in the range of low and high frequencies, specific absorption rate. Influence of ionizing radiation on biological systems, absorption law, quantities used in radiation protection and safety standards, radioactive decay law, characteristics of radioactive sources applied in medicine, brachytherapy and teletherapy, radioactive isotopes in diagnostics, gamma camera, scintigraphy, single photon emission tomography, positron emission tomography.	W1, W11, W12, W6, W9, U1, U13, U2, U3, K2	seminar, lecture

5.	Imaging diagnostics, X-ray apparatus, roentgenography, minimization of radiation doses and image optimization, pantomography, densitometry, computed tomography and principle of measurement, tomographic window, phenomenon of magnetic resonance, magnetic resonance tomography and principle of measurement, magnetic resonance spectroscopy, advanced ultrasound techniques (Doppler effect, higher harmonics, 3D and 4D imaging), types of contrast agents applied in various method of diagnostic imaging.	W1, W13, W17, W8, U1, U11, U13, U6, K2	seminar, lecture
6.	Lab classes include self-implementation by students experiments with the use of devices and organ models built at the Biophysics Department. Individual exercises concern the following issues: methodology of physical experiment (error calculation), measurement and data analysis of selected physiological quantities, acquisition and computer processing of diagnostic images, mechanical properties of bones, model of the circulatory system, hemodialysis, pharmacokinetics, subtractive angiography, ultrasonography, electrocardiography and electromyography, model of the respiratory system and spirometry, keratometry (eye model), audiometry (ear model), electrotherapy and magnetotherapy	W13, W14, W2, U11, U12, U5, U6, U7, U8, K1, K3, K4	laboratory

Course advanced

Teaching methods:

laboratories (labs), lecture

Activities	Examination methods	Credit conditions
lecture	oral answer	Participation in seminars, positive assessment of answers.
seminar	oral answer	Participation in seminars, positive assessment of answers.
laboratory	assignment report	Labs: report, each exercise is rated on a scale of 0-10 points. For getting credit it is necessary to get an average grade equal to minimum 6 points from all exercises.

Additional info

Medical Biophysics course completes the final test exam. The final exam is a test exam, 60 questions, 5 possible answers, one point is obtained for each correctly indicated answer. Time duration is 60 minutes. Passing the exam requires collecting 30 points. A lower score means failed exam. The final positive grade is determined by adding all the exam points (if passed) and bonus points collected on seminars and labs.

Entry requirements

Knowledge in physics, mathematics and chemistry at the basic level. Ability to adapt this knowledge to solve problems in biophysics. Ability to prepare for classes with the use of given literature and other learning materials.

Literature

Obligatory

1. I. P. Herman, Physics of the Human Body. Springer, Berlin, 2007.
2. J. Newman, Physics of the Life Sciences. Springer, Berlin, 2008.

Optional

1. R. K. Hobie, B. J. Roth, Intermediate Physics for Medicine and Biology, Springer, Berlin, 2007.
2. M. W. Cole, M. Strikman, . Spartalian, Application of Modern Physics in Medicine, Princeton University Press, Princeton, 2015.

Standard effects

Code	Content
B.U1	use knowledge of the laws of physics to explain the effects of external factors such as temperature, acceleration, pressure, electromagnetic field and ionising radiation on the body and its elements
B.U2	assess the harmfulness of the dose of ionising radiation and comply with the principles of radiological protection
B.U6	predict the direction of biochemical processes depending on the energetic state of cells
B.U9	operate simple measuring instruments and evaluate the accuracy of measurements made
B.U10	use databases, including online databases, and search for the necessary information using the available tools
B.U11	select appropriate statistical tests, conduct basic statistical analyses, use appropriate methods of presenting results, interpret the results of meta-analyses and analyze the probability of survival
B.U13	plan and perform simple scientific research and interpret its results and draw conclusions
B.U14	indicate the relationship between factors disturbing the balance of biological processes and physiological and pathophysiological changes
B.U15	identify sources of electrical signals in the body
B.U21	use on-line photo, audio and video libraries
B.U28	provide expert knowledge through simple IT techniques of knowledge representation such as a block diagram or a rule database
B.U30	use lecture platforms
B.W1	water and electrolyte management in biological systems
B.W3	terms: solubility, osmotic pressure, isotonia, colloidal solutions and Gibbs-Donnan equilibrium
B.W5	physical laws describing fluid flow and factors affecting vascular resistance to blood flow
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B.W31	basic laws of mechanics referring to the skeletal and muscular system
B.W37	rules of using materials published on the Internet (copyright, quoting law, methods of obtaining free materials)
O.K5	perceive and recognize own limitations and self-assessing educational deficits and needs
O.K7	use objective sources of information
O.K8	formulate conclusions from own measurements or observations

Code	Content
O.K9	implement the principles of professional camaraderie and cooperation in a team of specialists, including representatives of other medical professions, also in a multicultural and multinational environment
O.U3	plan the diagnostic procedure and interpret its results
O.W3	methods of diagnostic and therapeutic procedures appropriate for specific disease states
O.W5	methods of conducting scientific research