Univerza v Ljubljani
Medicinska fakulteta

COURSE DESCRIPTION AND STUDY REGULATIONS

Course: Biophysics

Study Programme: Medicine

Year of the Course: 1

Semester: Winter

Course type: Compulsory

ECTS credits: 7

Lecturer(s): Jure Derganc

Valid for academic year: 2018/2019

Participating Organisational Units: Institute of Biophysics

Date of issue: September 15th 2018

1. Course objectives

Students acquire the principles of quantitative problem solving in medicine. They learn the basic physical laws and their application to human physiology, diagnostics and medical treatment. They learn about the measurements of the physical parameters in simple systems.

2. Course description

The course is taught in the first semester, in the form of lectures (4 hours per week for 15 weeks), practical lessons/seminars (1 hour per week for 15 weeks) and laboratory lessons (2 hours per week for 15 weeks).

The aim of the practical lessons is to discuss and consolidate the topics that have been addressed in lectures, and apply the acquired knowledge to specific sets of problems. In laboratory lessons, the students perform a set of laboratory assignments and prepare lab reports. The assignment schedule for each student is announced at the beginning of the semester. The schedule of laboratory assignments is different for each student and does not follow the course of the lectures. Participation in practical and laboratory lessons is mandatory. In the event of a justified absence, the laboratory assignments can be re-scheduled by the assistant.

The on-going assessment of knowledge consists of regular evaluation at practical and laboratory lessons, and two preliminary exams (the first in the mid-semester and the second at its end). The final exam consists of a written and oral exam in the examination periods.

3. Description of assessment of knowledge and skills during the course

The on-going assessment of knowledge and skills during the course consists of evaluation at practical and laboratory lessons, and two preliminary exams (the first in mid-semester and the second at its end). The evaluation at practical and laboratory lessons is based on the student's knowledge demonstrated at the lessons, skills demonstrated at laboratory exercises, the quality of lab reports and the student's overall engagement in the lesson. The impact of the on-going assessments on the final exam is described in detail in Chapter 5. Final examination.

The application for the on-going assessment of knowledge via the Student Information System of FM is not required.

4. Eligibility requirements for the examination (course exam)

A required condition for entering the final exam is a positive grade in assessment of practical and laboratory lessons. Lab reports must be submitted and assessed before the beginning of the exam week.

5. Final examination (Course exam): description of examination procedure

The final examination comprises a written and an oral part. The examination application must be submitted in a timely manner via the Student Information System of FM (https://vismf.uni-lj.si/).

The final grade for the course is determined at the oral exam. The entrance grade for the oral exam is determined with respect to the total number of points scored in preliminary exams (each preliminary exam counts max 15 points), the evaluation of practical and laboratory lessons (max 20 points) and the written exam (max 50 points). The grade scale is described in the Regulations for Assessment of Knowledge and Skills for the Uniform Master's Study Programmes of Medicine and Dental Medicine. The student will only be admitted to the oral exam if he / she has a positive grade in the assessment of practical and laboratory lessons (at least 11 points) and a positive grade in the written exam (at least 25.2 points). The final grade is based on the performance at the oral exam and may be different from the entrance grade. In the case of justified absence from the preliminary exams, the missing grades can be acquired by answering additional questions at the oral exam. In the event of repeated examinations, the written part of the

examination is re-examined. Students who have failed the exam twice are admitted to the oral examination even with less than 25.2 points on the written exam.

The topics of the written exam (total duration 120 min) comprise lecture topics (60% of the written exam or 30 points), problem solving related to practical lessons (20% of the written exam or 10 points) and exercises related to laboratory lessons (20% of the written exam. 10 points). The topics of the preliminary exams (duration 45) comprise lecture topics (67% of the total or 10 points) and problem solving (33% of the total or 5 points). The correct answers in written exams are scored by 1 point, and wrong answers can result in a deduction of -0.2 points. At the oral exam, the knowledge gained in lectures, practical and laboratory exercises is evaluated. Students who did not show satisfactory knowledge in problem solving or laboratory-related exercises at the written examination receive additional questions from the relevant content at the oral examination.

The exam schedule is determined at the Council of the Year, at the beginning of the first semester.

6. Additional provisions related to student assessment

Permitted accessories for written exams are: a pen, a standard (non-graphic) scientific calculator, a ruler/protractor.

7. Fundamental study material and Supplement reading

Fundamental literature (the literature is freely accessible on the homepage of the Institute of Biophysics):

- Skripta Biofizika za medicino (lecture notes).
- B. Božič, J. Derganc, G. Gomišček, V. Kralj-Iglič, J. Majhenc., P. Peterlin, S. Svetina, B. Žekš: Praktikum iz biofizike (instructions for the laboratory classes).
- Več avtorjev: Zbirka računskih nalog za biofiziko (lecture notes).

Additional literature

- izbrana poglavja iz R. Kladnik: Visokošolska fizika, I, II in III del, Državna založba Slovenije, 1985.
- F. Sevšek: Biomehanika, Visoka šola za zdravstvo, 2004.
- S. Amador Kane. Intoduction to Physics in Modern Medicine. CRC Press, 2009.
- PP Urone et al.: College Physics, https://openstax.org/details/college-physics
- C.R. Nave et al.: HyperPhysics, http://hyperphysics.phy-astr.gsu.edu/
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8. Exam topics, clinical presentations and skills

Quantitative description of natural phenomena

1) physical quantities, units
2) basic mathematical functions, exponential changes (first-order reactions)
3) graphs, linearization, log-log graphs
4) non-linear dependence between quantities; Drain, integral

Mechanics

5) description of motion (position, velocity, acceleration and relations among them)
6) types of motion (uniform, accelerated, mixed, three-dimensional)
7) rotation (description, acceleration, analogy between linear and circular motion)
8) differences between point and rigid bodies, degrees of freedom
9) 2. Newton's law of motion (force, torque, mass, moment of inertia)

10) conservation of momentum and angular momentum
11) work, kinetic, rotational and potential energy, conservative and dissipative forces
12) conservation of mechanical energy
13) differences between solid substances, liquids, fluids and gases
14) fluids at rest
    i) pressure, Archimedes' principle
    ii) compressibility
    iii) surface tension
        (a) Laplace's law
        (b) wetting
        (c) capillary action
        (d) surfactants
15) elastic properties of matter
    i) tensile, shear, torsional load and corresponding Hook laws
    ii) strain-stress diagram for a simple elastic substance
16) fluids in motion
    i) description of flow, volume flow, flow rate vs. velocity, laminar/turbulent flow (Reynolds number)
    ii) Bernoulli's equation
    iii) square law of resistance
    iv) viscosity
    v) linear law of resistance: Stokes' law
    vi) velocity profile in the vessel, connection between the maximum and average velocity
    vii) Hagen-Poiseuille's law
    viii) Ostwald viscosimeter
17) sedimentation
18) mechanical equilibrium, centre of gravity (mass centre)
19) oscillations
    i) description of oscillation
    ii) examples of pendulums
    iii) resonant frequency
    iv) damped oscillation
    v) forced oscillation
    vi) resonance

Thermodynamics

20) basic characteristics of thermodynamic systems
21) thermal motion, diffusion
22) internal energy
23) the connection between the microscopic and the macroscopic picture of the ideal gas (gas equation, internal energy of ideal gas, partial pressure in gas)
24) temperature, temperature measurement and temperature scales
25) work, heat
26) 1st law of thermodynamics
27) calorimetry, specific heat, thermal capacity, heat of fusion and vaporization
28) specific heat of ideal gases
29) enthalpy, Hess' law
30) isothermal and adiabatic processes
31) entropy, microscopic image of entropy
32) 2. The law of thermodynamics
33) calculation of the entropy change
34) thermodynamic potential at a given p and T: free enthalpy (Gibbs energy)
35) multiphase systems, chemical potential, balance, equilibrium distribution of substances between phases (Boltzman factor)
36) chemical potential of ideal gas

37) dissolution of gases, chemical potential of the solute
38) osmotic pressure, chemical potential of the solvent
39) phase diagram of water
40) saturated vapour pressure, humidity
41) transport phenomena (Ohm's law, current, flux, stationary state, resistor combinations)
    i) heat transfer
    ii) diffusion
    iii) non-stationary state and approach to equilibrium
    iv) transport across the membrane (passive and active transport)
        (a) membrane permeability
        (b) facilitated transport

Electricity and magnetism

42) electric charge, charge in biological systems, pH
43) electric field and the electric force
44) electric potential, equipotential surfaces, voltage and energy of the electric field
45) electric dipole
46) torque on the electric dipole in the electric field
47) electric field in matter
    i) conductors (metal, ionic solution)
    ii) isolators (polarizability, dielectric materials, polarization)
48) the field near an infinite charged plate
    i) in an empty space
    ii) in a dielectric material
    iii) in an ionic solution (Debey's length)
49) capacitor
50) electric current
    i) effects of an electric current
    ii) mobility, specific conductivity, specific resistance, resistance, basic knowledge of electrophoresis
    iii) current dipole
    iv) Ohm's law, resistor combinations, electric power
51) origins of electric potential
    i) contact potential
    ii) electrode potential
    iii) the diffusion potential
    iv) membrane potential (Nernst's and Goldman's equation)
    v) membrane potential in the red blood cell (Donnan equilibrium)
52) ECG and basic knowledge of electroencephalography (EEG) and electromyography (EMG)
53) electric conduction in the nerve fibres
54) magnetic field
    i) magnetic field
    ii) Amper's law and basic knowledge of magnetoencephalography (MEG)
    iii) magnetic field of the current loop, the coils, the energy of the magnetic field
    iv) force between conductors
    v) force on a moving charge, basic knowledge of mass spectroscopy
    vi) Hall's effect
    vii) law of induction, basic knowledge of transcranial magnetic stimulation (TMS)
    viii) magnetic dipole and the torque in magnetic field
    ix) magnetic field in matter, a magnetization
55) alternating current
    i) effective voltage
    ii) capacitors and coils in an alternating-current
56) discharging and charging of capacitors

Fundamentals of molecular biophysics

57) hydrogen atom, the energy states of the atom, the shell, and the subshell, quantum numbers
58) atoms with several electrons
59) combining atoms into molecules, dissociation energy
60) strong interatomic bonds
    i) ionic bond, metal bond
    ii) covalent bond
61) spatial and electronic structure of simple molecules (H_2, O_2, H_2O, NH_3, CH_4)
62) electrical properties of substances: conductors, insulators, semiconductors
63) excited states of molecules
64) weak interatomic bonds
    i) polar interactions
    ii) hydrogen bond
    iii) Van der Walls interaction
    iv) hydrophobic interaction
65) properties of the water molecule
66) protein structure, peptide bond
67) DNA structure
68) lipid membrane structure

Waves

69) general characteristics of waves
    i) description (frequency, wavelength, velocity, phase)
    ii) energy flux, energy density
        (a) divergence / convergence of rays
        (b) law of absorption
    iii) reflection and refraction law, total reflection, basic knowledge of endoscopy
    iv) interference
    v) diffraction
    vi) diffraction grid
    vii) scattering
    viii) standing wave
    ix) spectrum
70) sound and ultrasound
    i) basic characteristics
    ii) sound intensity and decibels
    iii) Doppler effect
    iv) use of ultrasound in medicine
    v) hearing and speech
71) electromagnetic waves
    i) basic characteristics, the EM spectrum
    ii) energy of EM waves and quantum picture
    iii) fluorescence
    iv) thermal radiation
    v) light spectroscopy, photometer, basic knowledge of pulse oximeter
    vi) laser, medical use of laser
72) optics
    i) lens, lens power, lens equation, image formation, two-lens systems
    ii) magnification, simple magnifier
    iii) microscope, magnification, resolution
    iv) eye, accommodation, near-sightedness, far-sightedness
73) X-rays
    i) production of X-rays
    ii) spectrum

iii) interaction with matter
iv) use in medicine
v) basic knowledge of computer tomography (CT)

74) magnetic resonance
i) excitation and relaxation, relaxation times
ii) magnetic field gradient and a spatial picture

Atomic nucleus

75) nucleus composition, size
76) binding energy, mass defect
77) radioactivity, nuclear decay / reactions
i) alpha
ii) beta plus, beta minus, electron capture
iii) gamma
iv) nuclear fission
v) activity, half-life, decay constant
78) interaction of radioactive rays with matter
79) Geiger-Mueller tube
80) effects of ionizing radiation on tissue
81) doses
82) an overview of ionizing radiation
83) basic knowledge of the use of ionizing radiation in medicine: therapeutic irradiation (accelerators, brachytherapy, radioactive sources), diagnostics (PET, scintigraphy)

Miscellaneous

84) basics of measurement, analysis of measurements, evaluation of measurement errors
85) tracer methods, volume determination, determination of the velocity constant during the exchange of matter between compartments
86) two-exponential kinetics (the content of the Lab Assignment #2)

9. Other

Additional information on the study regime at the Faculty of Medicine is available in the Regulations for Assessment of Knowledge and Skills for the Uniform Master's Study Programmes of Medicine and Dental Medicine.