REQUIREMENTS

Semmelweis University
Host Institute:
Institute of Biophysics and Radiation Biology

Subject in Hungarian: Biofizika II.

Subject in English: Biophysics II.

Subject in German: Biophysik II.

Number of credits: 3

Number of lessons: 56 **lectures:** 21 **practices:** 35 **seminars:-**

Type of the subject: compulsory

Academic year: 2022/2023 2nd semester

Lecturer: Dr. Liliom Károly
Contact: Institute of Biophysics and Radiation Biology, +36 30 824-6229
Disposition: habil, senior research fellow

The goals of the course in point of view of the education:
Todays students will be the physicians of the oncoming decades. In selecting and highlighting topics of study, the first viewpoint is scientific foresight: the knowledge should be conveyed which must be pertinent to ensure first-class professional competence while keeping abreast of the most recent development in the field of study. Our aim is not only the teaching of a specific body of knowledge but also the development of the exact scientific method and concrete problem-solving abilities.

Location of the course (lectures and practices):
Basic Medical Science Center, 1094 Budapest, Tűzoltó u. 37-47.

Competences acquired by completion of the course: Students must be familiar in the basic principles of physics and mathematics

Pre-study requirements and prerequisites of course registration and completion: Biophysics I., Physical bases of Dental Materials

Number of students required for announcement of course *(min., max.)*: Number of students registered in NEPTUN system

Method of course registration:
Semmelweis University, Neptun system

Detailed course/lecture description[i]: *(to facilitate credit recognition in other institutions)*

No of weeks	Lectures - 1,5 h/week	Practices – 2,5 h/week
1	Radiaton therapy. Dosimetry of ionizing radiations I: physical and biological dose concepts, biological effects of ionizing radiation	Dosimetry
2	Dosimetry of ionizing radiations II: detectors for nuclear- and X-radiation; radiation protection	Coulter counter
3	Sound and Ultrasound (US): Physical properties and parameters of sound; generation of US; basic principles of medical application of US.	Amplification of electric signals
4	US imaging, A-, B-, and M.image, Doppler methods; US therapy.	Gamma-energy determination

5	Human body as a source of signals, types, detection, analysis and presentation of signals; basic principles of madical imaging,	X-ray, generation and absorption
6	MRI	ECG
7	Transport phenomena I: flow of fluids and gases in tubes, application of laws in living systems (blood and air flow)	Audiometry
8	Transport phenomena II: phenomenon of diffusion and its role in the living organism, osmosis	Pulse generators, pacemakers
9	Transport phenomena III	Gamma-camera
10	Modern methods in the investigation of biomolecular systems	Diffusion
11	Bioelectric phenomena I: physical interpretation and local changes of resting membrane potential	Flow of fluids
12	Bioelectric phenomena II description of excited state, generation and propagation of action potential	Sensory function
13	Basic principles of sensory function.	Concept of X-ray CT
14	High frequency heat therapy; pulse generators bases of electric diagnostic and therapeutic methods	Summary and repetition

Lecturers: Dr. Liliom Károly, Dr. Schay Gusztáv

Courses *(obligatory and elective)* which in part or entirely overlap the topics of above course: -

Special academic work required for completion of the course[ii]:-

Attendance on practices and lectures, replacement in case of missed sessions:
Participation in the practical lessons is compulsory. No more than three absences from practices are allowed for any reason, otherwise the semester will not be credited. Missed sessions must be reported to the teacher the week after. The missed measurements should be done with another group if possible. By the end of the practice lessons corresponding electric laboratory reports have to uploaded to the electronic system of the Institute.

Method of checking acquired knowledge during the study period[iii]:
It will be announced on the homepage of the department during the first week of the semester.

Requirements of an accepted semester *(signature of the lecturer)*: participation on at least 75 % of the practices; at least 50 % of the points possible to get from the two midterm tests are achieved; at least 75 % of uploaded laboratory reports must be confirmed by the practice teacher.

Type of the exam: oral exam/final

1. Radiation
   a) Properties and types of radiation
   b) Physical parameters of radiation
2. Law of attenuation of radiation
   a) Experimental interpretation of the law
   b) Forms and validity of the law
   c) Application of the law in medical and laboratory practice
3. Basic principles of optics I
   a) refraction of light; Fermat's principle; Snellius-Descartes law
   b) applications: prism, optical fiber
4. Basic principles of optics II
   a) Reflection, spectral reflectane
   b) Scattering : Rayleigh-, Mie-, Raman-scattering
5. Optics of the human eye

a) Image formation and power of the eye
b) Visual acuity, resolution of the eye; accommodation power, eyeglasses

6. Image formation by optical devices and their medical application
   a) Optical lenses, lens systems, microscope
   b) Resolution; Abbe's principle
7. Light as electromagnetic wave
   a) Parameters of electromagnetic waves
   b) Family of electromagnetic radiation; electromagnetic spectrum
8. Wave nature of light
   a) Superposition, interference
   b) diffraction, optical greating, dispersion of whit light
9. Corpuscular nature of light
   a) photoelectric effect (experiment and its interpretation); the photon concept
   b) application of photoelectric phenomenon
10. Absorption of light
   a) Mechanism of light absorption; the absorption spectrum
   b) Lambert-Beer's law and its medical application
   c) Measuring techniques: light sources, monochromators, detectors
11. Blackbody radiation
   a) absorption coefficient; radiant emittance; Kirchhoff's law
   b) origin of blackbody radiation
   c) Spectrum of blackbody radiation; Wiens's displacement law
12. Basic principles of telethermography
   a) Stefan-Boltzmann law
   b) Thermal radiation of human body
   c) Other application fields of thermal radiation
13. Luminescence
   a) Mechanisms of luminescence; Kasha's rule
   b) Emission spectrum, Stokes shift
   c) Life time of fluorescence and phosphorescence
14. Application fields of luminescence
   a) Light sources based on luminescence
   b) Medical and laboratory use of luminescence
15. Concept of light amplification
   a) Optical pumping and population inversion
   b) Induced emission
16. Production of LASER light
   a) Preconditions for LASER operation
   b) Emission and properties of LASER light
17. Medical application of LASERs
   a) Characteristics of LASER light
   b) Biological effects and medical application of LASER light
18. Generation of X-ray I.
   a) Structure and operation of X-ray tube
   b) Generation and spectrum of Bremsstrahlung
19. Generation of X-ray II.
   a) Power and efficiency of the X-ray tube
   b) Generation and spectrum of characteristic radiation
20. Absorption of X-ray
   a) Attenuation and mass attenuation coefficient
   b) Mechanisms of the absorption
21. Medical application of X-ray absorption
   a) Factors influencing X-ray absorption
   b) Basic principles of X-ray diagnostics and radiation protection
   c) Application of contrast materials
22. X-ray diagnostics I
   a) Summation image; fluoroscopy
   b) X-ray image amplifier; DSA
23. X-ray diagnostics II
   a) Concept of CT; Hounsfield units, spiral CT, spatial and temporal resolution
   b) Generations of CT

24. Nuclear radiation
    a) Composition and stability of the nucleus
    b) Nuclear forces; mass defect
25. Radioactive decay law
    a) Activity; definition and factors influencing its value
    b) Change of activity in time; decay constant, half life
26. α- and β-radiation
    a) α-particle; spectrum of α-radiation; interaction with matter
    b) Types, characteristics and spectrum of β-radiation; interaction with matter; annihilation
27. Gamma-radiation and its interaction with matter
    a) Nature, characteristics and spectrum of gamma-radiation; izomeric transition
    b) Interaction of Gamma-radiation with matter
28. Basic principles of diagnostic application of radioisotopes
    a) Basic principles and information provided by isotope diagnostics
    b) Selection rules for in vivo application of radioisotopes
29. Methods in isotope diagnostics I.
    a) Isotope accumulation curve; effective and biological half life
    b) Gamma camera (structure and operation); static and dynamic pictures
30. Methods in isotope diagnostics II.
    a) SPECT
    b) PET
31. Radiotherapy
    a) Types of radiation in radiotherapy and their absorption characteristics
    b) Relative depth-dose
32. Accelerators and therapeutic devices
    a) Linear accelerator and cyclotron
    b) Collimators
    c) Gamma knifes, brachytherapy
33. Dosimetry of ionizing radiation
    a) Absorbed dose (definition, unit, validity)
    b) Exposure, (definition, unit, validity);
    c) Measurement of exposure
34. Detection of ionizing radiation
    a) Devices based ion gas ionization
    b) Scintillation counter, thermoluminescent dosimeter
35. Ionizing radiation caused damages
    a) Characteristics of stochastic and deterministic damages; examples
    b) Radiophysics and radiochemistry of stochastic and deterministic damages.
36. Quantitative characterization of biological effects of ionizing radiation
    a) Equivalent dose effective dose; waiting factors;
    b) Origin and biological significance of background radiation
37. Natural and artificial sources of ionizing radiation
    a) Medical sources of ionizing radiation and natural background radiation
    b) ALARA principle
    b) PET
38. Basic principles of medical application of ultrasound
    a) Sound and ultrasound as mechanical waves; their parameters
    b) Propagation, absorption and reflection of US; acoustic impedance
39. Generation and detection of ultrasound
    a) Generation and detection of US
    b) US techniques, echo principle
40. Ultrasound imaging
    a) US image and its interpretation
    b) A-, B- and (T)M images
41. Doppler method; US therapy
    a) Doppler effect and its medical application
    b) Biological effects of US; US therapy
    c) Shock wave therapy
42. Basic principles of electricity
    a) Elements of electric circuits; properties and parameters

b) Electric behavior of biological structures

43. Detection and analysis of electric signals
    a) Classification of signals
    a) Electric amplifiers, types and parameters
    b) Fourier's principle
44. Interpretation of images made by various diagnostic methods
    a) image, pixel, voxel
    b) Interpretation and comparison of information held by various diagnostic images
45. Medical imaging methods
    a) Direct and computed tomographyc methods
    b) Non-tomographyc images - types and interpretation
46. Volume transport
    a) General characteristics of volume transport
    b) Comparison of the flow of ideal and real fluids
47. Flow of fluids and gases; methods for measuring the volumetric flow rate
    a) Law of continuity and the blood flow
    b) Bernoulli's law for ideal fluids (an example of its consequences for the blood flow)
48. Flow of real fluids
    a) Newton's law of friction (explanation and validity); its application for spherical particle
    b) Comparison of laminar and turbulent flow; critical velocity;
49. Description and modeling of blood flow
    a) Fluid flow in a tube; Hagen-Poiseuille's law (explanation and validity)
    b) Application of Hagen-Poiseuille law to blood-circulation; comparison of Hagen-Poiseuille'law and Ohm's law
50. Characteristics of molecular motion
    a) Qualitative description of molecular motion; thermal motion, Brownian motion, drift speed, mobility
    b) Visualization and quantitative characterization of molecular motion; mean free path, mobility
51. Diffusion
    a) Fick's first law; diffusion coefficient
    b) Generalized continuity-equation; Fick's second law and its meaning
52. Osmosis; osmotic phenomenon
    a) Explanation of the osmotic pressure; van't Hoff law
    b) Problems of osmotic pressure in practice; isotonic solutions
53. Thermodynamic aspects of transport processes
    a) Thermodiffusion; heat conduction
    b) Extensive and intensive quantities; uniform description of transport processes; Onsager-relation
54. Transport through cell membrane; chemical and electro-chemical potential
    a) Classification and characterization of transport processes
    b) Membrane permeability constant; diffusion of molecules; electrodiffusion
55. Interpretation of resting membrane potential
    a) Equilibrium model and electro-diffusion (transport) model
    b) Equivalent circuit model of cell membrane
56. Alteration of resting membrane potential I.
    a) Local changes of membrane potential
    c) Time constant and space constant of the cell membrane
57. Alteration of resting membrane potential II.
    a) Action potential; ion transport during action potential
    b) Depolarization threshold and its changes during action potential
58. Propagation of action potential
    a) Speed of signal propagation
    b) Synaptic signal transmission; spatial and temporal summation
59. Basic principles of sensory function I.
    a) Types of stimuli and modalities
    b) Types of receptors
    c) Phsyho-physical laws
60. Basic principles of sensory function II.
    a) receptor potential; Its parameters and role in signal transition
    b) Connection between stimulus intensity and parameters of receptor potential and action potential
61. Physical principles of functioning of sensory organs
    a) Biophysical basics of vision
    b) Biophysical basics of hearing

62. Medical applications of electric pulses I.
    a) High frequency heat therapy
    b) Galvan therapy; iontophoresis
63. Medical applications of electric pulses II.
    a) Stimulus characteristic curves
    b) Parameters of electric stimuli, pacemaker
64. Basic principles of ECG
    a) Heart muscle as source of electric signal
    b) Integral vector
    c) Electrodes and lead systems in ECG
65. Modern microscopic techniques
    a) Point Spread Function (PSF); Rayleigh criterion
    b) Fluorescence microscope
    c) Confocal laser scanning microscope; two photon excitation
66. Concept of electron microscopy
    a) resolution of electron microscope
    b) TEM, SEM
67. Biostatistics I
    a) Variable and probability distribution
    b) Normal distribution and its parameters
68. Biostatistics II
    a) Sample and statistical characteristics
    b) Estimation of the expected value
69. Biostatistics III
    a) linear regression
    b) correlation
70. Hypothesis testing I
    a) t-distribution; null-hypothesis;
    b) correlation t-test
71. Hypothesis testing II
    a) t-test for one sample. T-test for two samples
    β) χ^2 -test

Grading of courses[7]: The knowledge of students presented during the oral exam will be evaluated by a grade between 1-5. Midterm assessments are not included in the exam grading.

Exam registration: Semmelweis University, Neptun system

Rules of repeating exams: according to the regulation by The Study and Examination Policy

Supporting educational materials (textbooks, notes etc.)
Damjanovich-Fidy-Szöllősi (eds): Medical Biophysics (2009) Medical biophysics practices (Semmelweis Publisher, 2015) Essentials of Dental Radiography and Radiology (Elsevier 2013) Orvosi Biofizika (szerk. Damjanovich S., Fidy J., Szöllősi J.) Medicina Könyvkiadó Rt., Budapest, 2006. Uploaded e-materals

Signature of course lecturer: **Dr. Liliom Károly**
Signature of head of department: **Dr. Kellermayer Miklós**
Date of submission: 1st Sept 2021, Budapest

Opinion of OKB:
Notes from the Dean's Office:
Signature of Dean:

[i] Detailed and numbered for each week of theoretical and practical lessons one by one, indicating the names of lecturers and instructors

[ii] Eg. field practice, medical chart analysis, survey conducting, etc.

[iii] Eg. homework, report, midterm exam etc. Topics, dates, method of retake and replacement.