MEDICAL UNIVERSITY – PLOVDIV

FACULTY OF MEDICINE

SYLLABUS

IN

PHYSICS

Approved by the Department Council - Protocol №93/09.06.2022

Confirmed by the Faculty Council - Protocol №6/15.06.2022

Physics

Syllabus

Discipline	Final exam/ semester	Auditorium classes				ECTS non-auditorium classes	ECTS total	Academic hours in years and semesters
								1st year
Physics	I	Total	Lectures	Practices	ECTS			I
		90	45	45	3.0	3.0	6.0	3/3

DISCIPLINE: Physics

TYPE OF DISCIPLINE ACCORDING TO THE UNIFORM STATE REQUIREMENTS: Mandatory

LEVEL OF QUALIFICATION: Master (MSc)

FORMS OF TRAINING: : Lectures, laboratory practicals, seminars, research involvement for talented students.

YEAR OF TRAINING: 1-st year

DURATION OF TRAINING: one semester

ACADEMIC HOURS: 45 hours of lectures, 45 hours of practicals

TECHNICAL EQUIPMENT APPLIED IN THE TRAINING: Laboratory audiometers, portable Ultrasonography device, laboratory model of hemodialyzer, spectrophotometers, functional generators, oscilloscopes, electrotomy apparatus, optical and electrical transducers, microscopes, simulator of cardiac pacemaker, lasers.

FORMS OF EVALUATION: Practical tests, presentations, oral discussions, final exam

EVALUATION CRITERIA: The final grade (FG) is calculated according to the formula: FG = 0.3*X + 0.7*Y, where X is the accumulated grade from semestrial practical activity and tests, Y is grade from final exam.

ASPECTS OF EVALUATION CRITERIA:

1. **Running evaluation (criteria for the grade) –** activity and demonstration of knowledge during classes, participation in the laboratory exercises with building of manual technical and theoretical skills, ability to correctly measure, collect, analyze, and present data from experiments. Ability to make research (books, internet) in certain topics and to summarize useful information. Ability to present data in tables and graphs.
2. **Midterm evaluation** (average grade from all the running evaluations)
3. **Final grade** (result of final exam – combination of MCQ's test, written and oral exam).

SEMESTER EXAM: Written exam consisting of MCQ's test and open questions

STATE EXAM: no

LECTURER: Professor from department of Medical physics and Biophysics

DEPARTMENT: Medical physics and Biophysics

ANNOTATION

Medical physics subject has a place to build understanding and knowledge for the basic concepts significant as a ground for further educational upgrade for students in medicine and particularly in the fields related with:

- Mechanically based (sound and ultrasound) concepts and methods for diagnostics, imaging and therapy in medicine (including skills to measure blood pressure and to perform audiometry);
- Properties of surface of the liquids, abilities to modulate surface tension by surface-active substances, prediction of behavior and changes of certain physiological liquids properties by addition of positively and negatively active structures. Possible clinical use;
- Haemodialysis machine simulator – application of physical methods in evaluation of purification process parameters;
- Transducers principles, applications, types of transducers. Skills to use different transducers in laboratory and preclinical measurements.
- Basics of electro-diagnostics: passive and active methods. Rheography. Skin impedance measure. Experimental electro-muscle stimulation.
- Electrophoresis – preparatory paper based separation of fractions.
- Medical procedures with direct and alternating currents. Theory of therapy by electromagnetic fields.
- Origin of magnetic field. Human tissue sensitivity to magnetic field. Magnetic resonance imaging (MRI). Image formation.
- Visible light photons properties. Wave-particle duality. Reflection, refraction, full inner light reflection, light absorption and scattering. Light based methods in medicine.
- Ultraviolet radiation parameters, bands and their specific properties. Biological action of A, B and C bands radiation. Protection methods against harmful action of ultraviolet radiation.
- Properties of Infrared radiation and application in medical diagnostics.
- Luminescence processes in biology and medicine. Luminescent analysis.
- Parameters of laser radiation Medical applications of different wavelengths of coherent laser radiation. High intensity lasers in surgery. Low intensity interactions: photobiological effects, stimulation, photodynamic therapy.
- Observation of micro-objects in biological and medical investigations. Principles of optical microscopy. Requirements for magnification, resolution and method of observation depending on the type of the objects.

- Optical system of human eye. Physiological aberration in vision and methods Optic disorders, correction. Spectral sensitivity of the eye.
- Directly and indirectly ionizing radiations. Interactions between radiation and biological matter.
- X-rays production – roentgen tube. Medical applications of X-rays in imaging Computed tomography.
- Radioactivity. Radio-pharmaceutics as diagnostics agents. Rules and requirements in medical diagnostics by radio-pharmaceutics.
- Gamma-camera, SPECT- and PET- systems.
- Dosimetry of the ionizing radiations.
- Basics of radio-therapy. Linear accelerators, cyber knife, brachytherapy.

BASIC AIMS OF THE DISCIPLINE

The goal of the subject of medical physics is:

1. To form theoretical fundament of principles underlying medical diagnostics, and therapy;
2. To build practical skills in laboratory simulation of medical data acquisition;
3. To give opportunity for work with measuring, recording and displaying devises used in laboratory practice and research.

The main tasks of the course program are to build understanding for:

Fundamental physical laws underlying biological phenomena in human body.

The physical principles applied in laboratory and clinical techniques of measurement in medicine.

Potential of different physical agents to serve as medical information transduction and therapeutic instruments.

EXPECTED RESULTS

Upon completion of the lecture and practical course in medical physics, and successful pass the final exam, students are expected to become competent in:

1. Theoretical knowledge:

1.1 Understanding of basic quantities and units

1.2 Analytical and graphical presentation of physical relationships

1.3 Understanding the principles of basic medical equipment used for diagnostic and therapy.

2. Practical skills:

2.1 Conduction and analysis of an audiometric test;

2.2 Measurement and calculation of blood speed using Doppler ultrasound device;

2.3 Measurement of blood pressure;

2.4 Use of different types of transducers in measurements and plotting of graphs by data obtained;

2.5 Measuring of electric signals with oscilloscope;

2.6 Collecting and presenting experimental data in tables and graphs, with statistical analysis;

2.7 Determination of the amount of radionuclide used for diagnostics, and the dose for radiation treatment;

2.8 Application of appropriate methods in observations by optical microscope

2.9.Determination of the type and refractive power of correction lenses in case of eye visibility disorders.

LECTURES

№	LECTURE COURSES	HOURS
1.	1. Mechanical waves. Sound. Physical characteristics of sound: pressure, intensity, frequency, wavelength, propagation speed, acoustic impedance, spectrum. 2. Psychophysical characteristics of sound: intensity level, loudness, pitch, timber. Auditory area.	**3**
2.	3. Sound diagnostics and therapy methods: auscultation, blood pressure measurement, audiometry, phonocardiography, extracorporeal lithotripsy. 4. Ultrasound (US). Physical properties. Production and detection of US for medical purposes.	**3**

	5. US imaging. Ultrasonography modes.	
3.	6. US therapy. Sonophoresis. HIFU 7. Infrasound (IS). Physical properties. IS sources. Influence of IS on human body.	**3**
4.	8. Gradients. Transfer processes: diffusion, internal friction, heat conduction. Medical methods based on transfer processes. 9. Structure of liquids. Molecule pressure and surface tension. Additional (Laplace) pressure. Embolism.	**3**
5.	10. Movement of fluids. Laminar and turbulent flow. Steady flow. Poiseuille's law. 11. Blood flow in cardiovascular system. Pulse wave. 12. Mechanics of breathing. Surfactant.	**3**
6.	13. Direct, pulsing and altering current. Ohm’s law. Components of electric circuits and their properties. Impedance. 14. asound (IS). Physical properties. IS sources. Influence of IS on human body.	**3**
7.	15. One-way and two-way current rectification. 16. Electrodiagnostics: passive and active diagnostics. Transducers. EIT (electric impedance tomography). EMG, EEG, EKG. 17. Electrotherapy. Medical procedures with direct and alternating currents. Therapy by electromagnetic fields.	**3**
7.	18. Electro conductivity of electrolytes. Faraday’s law. Medical electrophoresis. 19. Electric currents in gases. Aeroions. Biological influence of aeroions. Ozone therapy.	**3**
8.	20. Magnetic properties of matter. Origin of magnetic field. 21. Magnetic resonance imaging (MRI). Image forming parameters ρ; T_1, T_2.	**3**

9.	22. Electromagnetic radiation – spectrum, parameters. Wave-particle duality. 23. Reflection, refraction, full inner reflection of light. Light absorption and scattering.	**3**
10.	24. Ultraviolet (UV) radiation: parameters, bands, sources of UV radiation. Biological action. Protection. 25. Infrared (IR) radiation: parameters, bands, properties, sources. Biological action and application in image diagnosis (thermovision).	**3**
11.	26. Luminescence. Atomic conversions in luminescent light emission. Characteristics and laws of luminescence. Diagnostic methods using luminescence. 27. Optical quantum generators - Lasers. Stimulated emission. Population inversion, three and four level scheme of generation. Laser components. Types of lasers. 28. Parameters of laser radiation Medical applications of laser radiation.	**3**
12.	29. Observation of microobjects in medicine. Microscope – optic scheme, magnification. Optical resolution. Observation modes by microscope. 30. Human eye - optic system, refractive power, reduced schematic eye. Optic disorders, correction. Spectral sensitivity of the eye. Color vision.	**3**
13.	31. Ionizing radiation. Directly and indirectly ionizing radiations. Interactions between photon radiation and matter: photoelectric absorption, incoherent scattering (Compton effect), couple (e--e+) production. Attenuation of the radiation. 32. X-rays (Roentgen radiation): nature, properties. Production of X-rays – roentgen tube. Characteristic and braking radiation.	**3**
14.	33. Medical applications of X-rays. X-ray imaging: radiography and radioscopy, conventional angiography, DSA, DEXA. Computed tomography. Hounsfield scale. 34. Radioactivity. Radioactive decays, parameters, law. Radio-pharmaceutics. 35. Nuclear medicine imaging. Gamma-camera, SPECT- and PET- systems.	**3**
15.	36. Dosimetry of the ionizing radiations. Dosimetric quantities and units: exposure, absorbed equivalent and effective dosage dose. Radiation and tissue weighting factor. 37. Basics of radio-therapy. LINAC, cyber knife, brachytherapy.	**3**

PRACTICES

Practical № 1 Error calculation of experimental results. Interpolation.	3h
Practical № 2 Audiogram – a method for diagnostics of the hearing apparatus	3h
Practical № 3 Physical basis of Doppler ultrasound imaging	3h
Practical № 4 Comparison of blood pressure values measured by two techniques – sphygmomanometry and oscillotonometry	3h
Practical № 5 Physical basis of hemodialysis. Hemodialyzer	3h
Practical №6 Transformation of non-electrical quantities. Calibration of semiconductor thermometer and photoelement	3h
Practical №7 Rectifiers. Determination of the parameters of low frequency alternating current pulses.	3h
Practical № 8 Generators of high frequency electromagnetic waves. Frequency ranges used in physiotherapy. Inductive and capacitive methods. Determination of the power of electromagnetic wave sources. Safety technique	3h
Practical № 9 Calculation of magnification and resolution of an optical microscope and choice of observation technique.	3h
Practical № 10 Possibilities for correcting myopia, hypermetropia, astigmatism and strabismus by optical lenses	3h
Practical № 11 Determination of beam divergence and power of a He-Ne laser	3h
Practical № 12 Practical assignments related to the types and quantities of radionuclides used in nuclear medicine	3h

Practical № 13 Obtaining the energy spectrum of the radionuclide ^{99m}Tc and determination of the position and width of the energy "window" of the installation for radionuclide diagnostics 3h

Practical № 14 Determination of irradiation duration and/or monitoring units in radiation therapy with high energy ionizing radiation 3h

Practical № 15 Seminar. 3h

BIBLIOGRAPHY

Lecture notes in medical physics, V. Turiyski, (electron format), 2021
Biophysics Multiple Choice Questions Booklet, Edited by Prof. Atanas Krastev, DBSc, First Edition – 2018
Notebook in medical physics – Edition 2017

SYLLABUS IN MEDICAL PHYSICS

Mechanics (acoustics and rheology)

1. Mechanical waves. Sound. Physical characteristics of sound: pressure, intensity, frequency, wavelength, propagation speed, acoustic impedance, spectrum.
2. Psychophysical characteristics of sound: intensity level, loudness, pitch, timber. Auditory area.
3. Sound diagnostics and therapy methods: auscultation, blood pressure measurement, audiometry, phonocardiography, extracorporeal lithotripsy.
4. Ultrasound (US). Physical properties. Production and detection of US for medical purposes.
5. US imaging. Ultrasonography modes.
6. US therapy. Sonophoresis. HIFU
7. Infrasound (IS). Physical properties. IS sources. Influence of IS on human body.
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9. Structure of liquids. Molecule pressure and surface tension. Additional (Laplace) pressure. Embolism.

10. Movement of fluids. Laminar and turbulent flow. Steady flow. Poiseuille's law.

11. Blood flow in cardiovascular system. Pulse wave.

12. Mechanics of breathing. Surfactant.

Electricity and Magnetism

13. Electric currents. Electric conductivity. Conductors, semi-conductors and dielectrics.

14. Direct, pulsing and altering current. Ohm's law. Components of electric circuits and their properties. Impedance.

15. One-way and two-way current rectification.

16. Electrodiagnostics: passive and active diagnostics. Transducers. EIT (electric impedance tomography). EMG, EEG, EKG.

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18. Electro conductivity of electrolytes. Faraday's law. Medical electrophoresis.

19. Electric currents in gases. Aeroions. Biological influence of aeroions. Ozone therapy.

20. Magnetic properties of matter. Origin of magnetic field.

21. Magnetic resonance imaging (MRI). Image forming parameters ρ; T_1, T_2.

Non-ionizing electromagnetic radiation

22. Electromagnetic radiation – spectrum, parameters. Wave-particle duality.

23. Reflection, refraction, full inner reflection of light. Light absorption and scattering.

24. Ultraviolet (UV) radiation: parameters, bands, sources of UV radiation. Biological action. Protection.

25. Infrared (IR) radiation: parameters, bands, properties, sources. Biological action and application in image diagnosis (thermovision).

26. Luminescence. Atomic conversions in luminescent light emission. Characteristics and laws of luminescence. Diagnostic methods using luminescence.

27. Optical quantum generators - Lasers. Stimulated emission. Population inversion, three and four level scheme of generation. Laser components. Types of lasers.

28. Parameters of laser radiation Medical applications of laser radiation.

29. Observation of microobjects in medicine. Microscope – optic scheme, magnification. Optical resolution. Observation modes by microscope.

30. Human eye - optic system, refractive power, reduced schematic eye. Optic disorders, correction. Spectral sensitivity of the eye. Color vision.

Ionizing radiation

Ionizing radiation. Directly and indirectly ionizing radiations. Interactions between photon radiation and matter: photoelectric absorption, incoherent scattering (Compton effect), couple (e^--e^+) production. Attenuation of the radiation.

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