# MEDICAL UNIVERSITY – PLOVDIV

# FACULTY OF MEDICINE

## PROGRAM

## IN

# PHYSICS

**Approved by the Department Council - Protocol № 82 /01.09.2020**

**Confirmed by the Faculty Council - Protocol № 5 /08.07.2020**

**Physics**

**Syllabus**

| Discipline | Final exam/ semester | Academic hours | | | | Academic hours in years and semesters | |
|---|---|---|---|---|---|---|---|
| | | | | | | 1st year | |
| Physics | I | Total | Lectures | Practices | ECTS | 1st sem. | 2nd sem. |
| | | 90 | 45 | 45 | 6.9 | 3/3 | |

**COURSE NAME:**
Physics

**TYPE OF DISCIPLINE ACCORDING TO THE UNIFORM STATE REQUIREMENTS:**
Mandatory

**LEVEL OF QUALIFICATION:**
Masters /M/

**FORMS OF TRAINING:**
Lectures, laboratory practices, seminars, research opportunities for talented students.

**YEAR OF TRAINING:**
1st year

**DURATION OF TRAINING:**
One semester

**ACADEMIC HOURS:**
45h of lectures, 45h of laboratory

**TECHNICAL EQUIPMENT APPLIED IN THE TRAINING:**
Microscopes, Audiograph machines, Model of hemodialysis machine, Impulsed generator, Oscilloscope, Multi-meters, Laser, Optical sensors, Power meter, Optical model of human eye, Scintillation detectors, Dosimeters and Isodose curves

**FORMS OF EVALUATION:**
Practical tests, oral exam and final exam.

**EVALUATION CRITERIA:**
Final grade is calculated according to the formula: Final Grade = $0.3*X+0.7*Y$, where X is the accumulated grade from practical tests, and Y is the grade from the final exam.

**ASPECTS OF EVALUATION CRITERIA:**

1. Running evaluation – (criteria for the grade) – demonstration of knowledge during classes, participation in the laboratory exercises, the ability to collect, analyses, and present data during laboratory practices.
2. Midterm evaluation (average grade from the running evaluation).
3. Final grade (after final exam – entry test, written and oral exam).

**SEMESTER EXAM:**

Written exam based on multiple choice and open questions.

**STATE EXAM:**

No

**LECTURER:**

Professor from the department of Medical Physics and Biophysics.

**DEPARTMENT:**

Medical Physics and Biophysics

## ANNOTATION:

Physics is one of the fundamental courses studied by students at Medical University-Plovdiv. The course is mostly theoretical. It discusses the physical nature of the fundamental processes in bases of the modern medical diagnostics. The students learn some common principles upon which fundamental phenomena such link to mechanical and electromagnetic waves, electricity, magnetism and optics, ionizing radiation. This course clarifies the physical laws and their applications in medicine. The theoretical part also describes influence of external factors - electric current, visible light, ultraviolet and infrared rays and ionizing radiation on human health.

## BASIC AIMS OF THE COURSE:

To build fundamental understanding of:

- mechanical processes related to waves and sound (generation, propagation, interaction with the environment, production of perception in humans); psychophysical characteristics and quantities related to sound perception; acoustic methods in diagnostics and therapy (including ultrasound systems); basic principles of mechanical and thermal transfer processes and their application in medicine; surface properties of fluids; laws of movement of fluids including blood flow dynamics.

- basics in electricity (charges, fields, potentials, electromotive forces); types of electric currents and their characteristics; components of electric circuits and quantities related; applications of electric currents in medicine in diagnostics and therapy; magnetic properties of matter, origin of magnetic forces and interactions; nuclear magnetic resonance, its preconditions and quantities involved; parameters of magnetic resonance imaging.

- nature of light; wave-particle duality, emission, absorption and diffraction of light; light reflection and refraction, total internal reflection and its application in medicine; attenuation of photon beams, quantitative aspects and applications; light scattering; properties of ultraviolet radiation, biological effects and protection; properties of infrared radiation and medical applications; types of luminescence and analytic methods based on luminescence; optical quantum generators – lasers, properties of laser radiation and medical applications.

- ionizing radiation properties and types; interaction of directly and indirectly ionizing radiation with matter; quantitative evaluation of radiation attenuation; roentgen rays, properties; principles of roentgen rays image formation, contrasts; methods of diagnostics and therapy with roentgen rays; computed tomography; PET imaging, gamma camera; dosimetry in ionizing radiation diagnostics and therapy.

## EXPECTED RESULTS

**Acquiring the knowledge and the skills to explain, distinguish or measure:**

- Physical and psychophysical characteristics of sound: pressure, intensity, frequency, wavelength, propagation speed, acoustic impedance, spectrum, intensity level, loudness, pitch, timbre; parameters of auditory area.
- Diagnostics and therapy methods: auscultation, audiometry, phonocardiography, extracorporeal lithotripsy; blood pressure measurement, ultrasonography modes, sonophoresis, HIFU; production and detection of us for medical purposes.
- Diffusion, internal friction, heat conduction and medical methods based on transfer processes.
- Molecular pressure and surface tension, additional (Laplace) pressure. Embolism.
- Laminar and turbulent flow of liquids; laws of steady flow and Poiseuille; blood flow in cardiovascular system.
- Properties of conductors, semi-conductors and dielectrics; direct, pulsing and alternating currents, Ohm's law, electric impedance.
- Electrodiagnostics and electrotherapy' eit (electric impedance tomography). EMG, EEG, EKG, diathermy, HF electromagnetic and magnetic methods
- Biological influence of aeroions
- MRI forming parameters: $\rho$, $T_1$, $T_2$.

- Non-ionizing electromagnetic radiations spectra and parameter, optical properties of matter media; reflection, refraction, full inner reflection, absorption and scattering of light
- Dose-dependency of ultraviolet and infrared radiation effects upon humans, sun protection factors and requirements; thermo-vision.
- Atomic conversions during emission of luminescent photons; laws of luminescence.
- Stimulated emission, population inversion, three and four level energy diagram of photon generation; laser components, laser radiation parameters.
- Optical scheme, magnification and resolution of microscope; observation technics.
- Directly and indirectly ionizing radiations; photoelectric absorption, incoherent scattering (Compton effect), couple ($e^-$ - $e^+$ ) production; quantities and relations at radiation attenuation.
- Production of X-rays – Roentgen tube; characteristic and braking radiation; radiography and radioscopy, angiography, DEXA, computer tomography, Hounsfield scale.
- Radioactive decays, parameters, law; concept of radio-pharmaceutics application as an instrument.
- Imaging by gamma-camera, SPECT – and PET – systems.
- Exposure, absorbed-, equivalent- and effective dose, radiation- and tissue weighting factor.
- Principles in radiotherapy, LINAC, cyber knife, brachytherapy.

## PROGRAM OF PHYSICS LECTURES

**Lecture № 1 – 3 hours**

Mechanical waves. Sound. Physical characteristics of sound: pressure, intensity, frequency, wavelength, propagation speed, acoustic impedance, spectrum.

Psychophysical characteristics of sound: intensity level, loudness, pitch, timbre. Auditory area.

**Lecture № 2 – 3 hours**

Sound diagnostics and therapy methods: auscultation, blood pressure measurement, audiometry, phonocardiography, extracorporeal lithotripsy.

Ultrasound (US). Physical properties. Production and detection of US for medical purposes.

**Lecture № 3– 3 hours**

US imaging. Ultrasonography modes.

US therapy. Sonophoresis. HIFU

**Lecture № 4 – 3 hours**

Infrasound (IS). Physical properties. IS sources. Influence of IS on human body.

Gradients. Transfer processes: diffusion, internal friction, heat conduction. Medical methods based on transfer processes.

**Lecture № 5 – 3 hours**

Structure of liquids. Molecule pressure and surface tension. Additional (Laplace) pressure. Embolism.

Movement of fluids. Laminar and turbulent flow. Steady flow. Poiseuille's law. Blood flow in cardiovascular system. Pulse wave.

**Lecture № 6 – 3 hours**

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

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

**Lecture № 7 – 3 hours**

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

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

**Lecture № 8 – 3 hours**

Magnetic properties of matter. Origin of magnetic field.

Magnetic resonance imaging (MRI). Image forming parameters:$\rho$, $T_1$, $T_2$.

**Lecture № 9 – 3 hours**

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

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

**Lecture № 10 – 3 hours**

Ultraviolet (UV) radiation: parameters, bands, sources of UV radiation. Biological action. Protection. Infrared (IR) radiation: parameters, bands, properties, sources. Biological action and application in image diagnosis (thermo-vision).

**Lecture № 11 – 3 hours**

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

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

**Lecture № 12 – 3 hours**

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

**Lecture № 13 – 3 hours**
Medical applications of X-rays. X-ray imaging: radiography and radioscopy, conventional angiography, DSA, DEXA. Computer tomography. Hounsfield scale.

**Lecture № 14 – 3 hours**
Radioactivity. Radioactive decays, parameters, law. Radio-pharmaceutics.

**Lecture № 15 – 3 hours**
Gamma-camera, SPECT- and PET- systems.

## PRACTICAL COURSE SYLLABUS

| | | |
|---|---|---|
| 1. | Error calculation of experimental results. Interpolation. | 3h |
| 2. | Audiogram – a method for diagnostics of the hearing apparatus | 3h |
| 3. | Physical basis of Doppler ultrasound imaging | 3h |
| 4. | Comparison of blood pressure values measured by two techniques – sphygmomanometry and oscillotonometry | 3h |
| 5. | Physical basis of hemodialysis. Hemodialyzer | 3h |
| 6. | Transformation of non-electrical quantities. Calibration of semiconductor thermometer and photoelement | 3h |
| 7. | Rectifiers. Determination of the parameters of low frequency alternating current pulses. | 3h |
| 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 |
| 9. | Calculation of magnification and resolution of an optical microscope and choice of observation technique. | 3h |
| 10. | Possibilities for correcting myopia, hypermetropia, astigmatism and strabismus by optical lenses | 3h |
| 11. | Determination of beam divergence and power of a He-Ne laser | 3h |
| 12. | Practical assignments related to the types and quantities of radionuclides used in nuclear medicine | 3h |

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
14. Determation of irradiation duration and/or monitoring units in radiation therapy with high energy ionizing radiation — 3h
15. Seminar. — 3h

## Bibliography:


1. Emilia Milieva, Franco Milano, Iordan Kostourkov, MartiannaYaneva, Lubka Mihova – "Physics and Biophysics of Clinical Radiation Therapy" – 2017
2. Notebook in Medical Physics – 2017
3. Booklet of Multiple Choice practice test questions in Medical Physics, Edited by Prof. Atanas Krastev, DBSc – 2018


## Syllabus in 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.
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.
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.
17. Electrotherapy. Medical procedures with direct and alternating currents. Therapy by electromagnetic fields.
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: $\rho$, $T_1$, $T_2$.

**Non-ionizing electromagnetic radiation**

22. Electromagnetic radiation – spectrum, parameters. Wave-particle duality.
23. Reflection, refraction, full inner light 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 (thermo-vision).
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. (from practical exercises)
28. Parameters of laser radiation Medical applications of laser radiation.(individual project)
29. Observation of micro objects in medicine. Microscope – optic scheme, magnification. Optical resolution. Observation modes by microscope. (from practical exercises)
30. Human eye - optic system, refractive power, reduced schematic eye. Optic disorders, correction. Spectral sensitivity of the eye. Color vision.

**Ionizing radiation**

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.
33. Medical applications of X-rays. X-ray imaging: radiography and radioscopy, conventional angiography, DSA, DEXA. Computer tomography. Hounsfield scale.

34. Radioactivity. Radioactive decays, parameters, law. Radio-pharmaceutics. (from practical notebook)
35. Nuclear medicine imaging. Gamma-camera, SPECT- and PET- systems. (from practical notebook)
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.