MEDICAL UNIVERSITY – SOFIA

FACULTY OF DENTAL MEDECINE

CURRICULUM

Name of the discipline: MEDICAL PHYSICS

Educational degree: Master

Type of the discipline: obligatory

Course duration: one semester

Course degree: M degree (Master's)

Evaluation methods: During the practical exercises the students are subjected to **continuous assessment;** at the end of the semester **an exam on the practical exercises** is carried out in form of **a test**; **the final exam** on the whole course (covering the learning material from the lectures and practicum) contains written answers and discussion on them.

Training methods used during the course: Lectures – 45 hours, **practical** (**laboratory**) **exercises** – 30 hours; before coming to the laboratory exercises the students **have to prepare themselves on a given topic** from recommended reference sources (textbook, laboratory guide); during the practicum the basic training form is **the discussion**; after finishing the laboratory practice the students have to write **an individual standard protocol** concerning the experimental work, the obtained results and their discussion – **working out this protocol** is important part of the training.

Final exam at the end of semester: YES

Leading instructor: Associated professor DIMITAR MIHOV, PhD.

Home department: DEPARTMENT OF MEDICAL PHYSICS AND BIOPHYSICS

ANNOTATION OF THE COURSE: The Course of Medical Physics gives opportunity of the student of Dental Medicine to get fundamental knowledges and competence in the field of Physics and its applications in Dental Medicine. Physics is of general educational value for all medical universities students. The teaching in PHYSICS has a purpose the students:
1. To get important theoretical and practical knowledges.
2. To learn some topics concerning to their future dental practice like:
- Structure of solids, kinds of deformations, Robert Hooke law.
- Hardness and how to measure it.
- Bernoulli's equation, applications in dental practice.
- Temperature and Heat. Linear thermal expansion. Volume thermal expansion. Transfer of heat.
- Electric conductivity. Zone theory of electric conductivity. Electric resistivity of biological objects.
- AC current. Electrical safety.
- Electrography. Electric stimulation, electric pulses of different shape, applications.
- Therapy with direct electric current. Therapy with pulse electric current having low frequency.
- Defibrillators. Pacemakers. Electric therapy with alternating current having high frequency.
- Total internal reflection, fiber optics, endoscopy.
- UV rays, properties. Sources and detectors. Medical applications.
- Optical lenses, centered optical systems, optical devices, applications.
- Light microscope. Different microscope methods.
- Electron microscope. Transmission and Scanning electron microscopes.
- Outer and inner photoelectric effect.
- Photodiode. Charge-coupled device. Devices using CCD with application in dental medicine.
- Laser. Principle of working. Different kinds of Lasers. Some applications in dental practice.
- NMR. Nuclear magnetic resonance imaging.
- X-rays. X-ray tube. Principles of Roentgen diagnosis. X-rays protection.
- Radionuclide investigations.

COURSE OUTLINE: The course duration is 75 academic hours divided as follows:
Lectures - 45 hours
Practical exercises: 30 hours

Formation of the overall mark for the course:

- **Final examination** – the mark for written answers on two theoretical questions from the lecture course material and discussion on them; eventually additional questions – 75 %
- **Final mark for the practicum** (25%) – formatted on the basis of:
    - **Average mark** from the **continuous assessment**
    - **The mark** from the **final test** on the practicum

ASPECTS OF THE STUDENT'S EVALUATION:

During the practical exercises:

- Assessment of the students ability to obtain knowledge working individually with the reference sources.
- Evaluation of the students participation in the discussion on the keywords given.
- Assessment of the students experimental work in the laboratory.
- Evaluation of the students skills to process statistically the obtained results (by using computer programs and to represent them in tables, graph and to discuss them in the context of the aim of the study.

During the final examination:

- Assessment of the ability of the students to give written answers on the questions.
- Evaluation of the students skill to react on additional questions concerning his written answers and on other additional questions.

RESOURCES USED DURING THE COURSE:

Lectures: - computer based multimedia presentation
Laboratory practice: experimental set-ups, calculations, computers

Course objectives:
The students should gain knowledge and skills for introduction of physical methods (theoretical, experimental, and instrumental) in the organization of dental medicine care in accordance with the modern European standards in Health service.
Course goals:

1. Students have to gain the basic knowledge from the Lecture course.
2. Students should learn the experimental methods introduced in the laboratory exercises.
3. Students have to learn to process statistically (calculate mean values and standard deviations, do linear and non-linear regressions using statistical programs as Excel and Prism) the obtained experimental results and to represent them in tables, graph and to discuss them in the context of the aim of the study.
4. After finishing the laboratory practice the students have to be able to work up the experimental results and to write **a standard protocol** concerning to the final results.

REQUIREMENTS:

Successful finished courses in high school: physics, mathematics, chemistry and biology.

A PURPOSE OF A TRAINING COURSE

The purpose of the training on Medical Physics is to get knowledge and practical skills concerning to:

- Determining of physical quantities only with units from SI (International System of Units) which is the world's most widely used system of measurement, both in everyday commerce and in science
- How to measure the dynamic coefficient of viscosity;
- Measuring the spectral characteristic of the ear;
- Determining by lensmeter a refraction of optical lenses and prisms;

- Determining of the **Young's modulus** of elasticity of compact bone;
- Observing and analysis of atomic and molecular spectra;
- Determining of the natural background ionizing radiation;
- How to measure monochromaticity, coherence and directionality of laser light generated by He-Ne Laser;
- How to measure the coefficient of refraction of liquids by refractometer;
- Determining of the total linear attenuation coefficient for gamma-rays;

LEARNING OUTCOMES:

After ending of the lecture course the students

- have to understand all processes connected with the application of ultrasound in dental practice;
- have to understand all processes connected with the work of a suction pump in relation with the Bernoulli's equation;
- have to understand that the repeated X-ray investigations increase the risk for the patient in connection with harmful influence of ionizing radiation;
- have to look for modern technical devices using lasers and CCD (charge – couple-device) in theirs future dental practice;
- have to estimate the importance of hardness of different materials for dental practice;
- have to estimate the importance of thermal conductivity and volume thermal expansion for dental practice;
- have to work with different UV devices realizing how to protect themselves from UV harmful effect;
- have to understand all usable methods for electric therapy;
- have to understand all usable methods for electric diagnostics;
- have to work with different electric devices in conditions of electric safety only;
- have to understand the importance of fibre optic devices using for quality image of the treated object;

The practical skills offered to the students aim to familiarize them with basic knowledge about methods used in research and clinical laboratories.

In the practice the students learn:

- to formulate concrete aims and problems for experimental study;
- based on the knowledge offered in these materials, the students must be able to propose and discuss ideas about how the aims of the experiments have to be realized;
- to process statistically the obtained experimental data and represent them in tables and graphs;
- to comment the importance and application of the obtained information about the particular object investigated in physical and medical context;
- to document precisely the discussion, the experimental work and results in a protocol, which is close in form and structure to a scientific paper.

LITERATURE FOR PREPARATION:

1. Lectures – reprints of each one given to the students.
2. D. Ewen, R. Nelson, N. Schurter, E. Gundersen. Applied Physics, 2004, 768pp.
3. D. Halliday , R. Resnick, J. Walker. Fundamentals of Physics Extended, 2007, 1328 pp.

TOPICS FOR INDIVIDUAL PREPARATION: Themes connected to the laboratory exercises.

MEDICAL UNIVERSITY – SOFIA

FACULTY OF DENTAL MEDECINE

Department of Medical Physics and Biophysics

PROGRAM OF THE MEDICAL PHYSICS COURSE

FOR STUDENTS OF DENTAL MEDICINE

Lectures - 45 hours,
Course Duration: one semester, the first semester
(Odd weeks - 2 hours, even weeks - 4 hours)

I. MECHANICS - 5 hours

Theme 1. Basic principles and quantities of mechanics – 2 hours

Velocity, acceleration, forces, impulse, laws of motion, linear motion, Newton's laws, work, kinetic energy, potential energy, conservation of energy, different kind of movement, pressure, density. Atmospheric pressure, dependence of atmospheric pressure from the altitude, influence of atmospheric pressure upon human organism.

Circular motion. Angular momentum, uniform circular motion, non-uniform circular motion, centripetal acceleration, centripetal force, angular velocity, moment of inertia, angular momentum. Influence of inertia forces upon human organism.

Theme 2. Motion of ideal fluids – 2 hours

Basic concepts and laws – continuity of the flow, Bernoulli's equation. Medical applications. Laminar and turbulent motion. Blood pressure measurement.

Motion of real fluids. Newton's law for inner friction. Poeuaseu's law, viscosimetry. Non-Newton's behavior and micro rheological processes.

Theme 3. Separation of the phases in liquid heterogeneous systems – 1 hour

Sedimentation and centrifugation. Velocity of sedimentation force of centrifugation, Centrifuges – device, different types. Inertial forces effect upon human organism.

II. AQUSTICS - 3 hours

Theme 4. Sound. Psychophysical characteristic of sound. Ultrasound - 3 hours

Mechanical oscillations and waves – basic quantities and equations. Principles of Extracorporeal lithotripsy. Velocity of the sound, Doppler's effect, physical characteristics of the sound. Field of hearing. Psychophysical parameters of sound. Vocal apparatus of human. Noise protection. Acoustic methods for diagnostics. Infrasound.

Producing, general characteristics and effect of the ultrasound. Principles of ultrasound diagnostics, Doppler sonography. Medical application of ultrasound, drug ultraphonophorhesis.

III. MOLECULAR PHYSICS. THERMODYNAMICS - 6 hours

Theme 5. Structure of liquids and Structure of solids - 2 hours

Surface tension. Molecular pressure. Phenomenon on boundary between two different phases – menisci, capillarity. Gas embolisms. Trickling.

Amorphous solids, crystalline solids, liquid crystals. Robert Hooke law. Strength and hardness.

Theme 6. Thermodynamics - 4 hours

Temperature and heat. Zeroth Law of Thermodynamics. Temperature Scales. Linear Thermal Expansion. Volume Thermal Expansion. Phase Change of Water. Specific Heat Capacity. Calorimetry. The first law of thermodynamics, statements of the First Law. Macroscopic state of a system. Some common

thermodynamic processes: isochoric process (isovolumetric process), isobaric process, isothermal process, adiabatic process. quasi-static process, thermodynamic equilibrium, cyclic process, reversible process and irreversible process. Second law of thermodynamics, a statement of the Second Law. Heat Engines and the Carnot Cycle. the efficiency. Refrigerators, Air Conditioners. Order, Disorder, and Entropy. The third law of thermodynamics. Thermal exchange by radiation and absorption
Basic conceptions and quantities of thermal radiation. Kirchoff's law, Stefan Boltzman's law, Wien's law. Thermostats, thermo regulators, sterilizers.

IV. ELECTRICITY AND MAGNETISM - 8 hours

Theme 7. Electricity - 3 hours

Electric field. Magnitude of electric field. Electric potential. Dipolar molecules in electric pole. Parallel plate capacitor. Electric capacity of conductors.
Electric conductivity of solids. Zone theory of electric conductivity. Electric conductivity of metals. Conductivity of intrinsic semiconductors; conductivity of semiconductors with impurities. Thermistors and bolometers.
Electric Current. Resistance and Ohm's Law. Resistors in Series and Parallel. Ammeters and Voltmeters. Alternating Current. Capacitors in AC Circuits. RC Circuits. Inductors in AC Circuits. RLC Circuits. Resonance in Electrical Circuits. Electrical Safety.

Theme 8. Magnetism - 2 hours

Magnetic field. Magnitude of magnetic field, magnetic field lines. Motion of a Charged Particle in a Uniform Magnetic Field. Lorentz force. Mass Spectrometer. Cyclotron
Magnetic properties of a matter. Dia-magnetics, para-magnetics and ferro-magnetics. Hysteresis. Mechanical moment and magnetic moment of an electron as well of an atom. Electron paramagnetic resonance, applications.

Theme 9. Electric diagnostics and electric therapy - 2 hours

Physical base of electric diagnostics. Electrography, heart as an electric dipole. Electric stimulation – electric stimulation of tissues, diagnostic parameters, pulses of different shape, applications. Transducers of non-electrical quantities.
Physical base of electric therapy. Therapy with direct electric current. Therapy with pulse electric current with low frequency. Defibrillators. Pacemakers. Electric therapy with alternating current having high frequency. Electromagnetic field and its effect on a man, critical organs.

Theme 10. Electromagnetic field - 1 hour

Magnetic flux. Electromagnetic induction, mutual inductance, self-inductance. Electromagnetic(EM) waves, Maxwell's equations. Speed of EM waves. EM spectrum.

V. OPTICS - 8 hours

Theme 11. Light, geometrical optics, laws - 5 hours

Photometric quantities and units. Spectral sensitivity of human eye. Reflection and refraction of light, laws. Ophthalmoscope. Total internal reflection, fiber optics, endoscopy. Refractometry.
Dispersion and absorption of light. Normal and abnormal dispersion. Absorption of light, Lambert-Beer's law. Colorimetry and photometry of cells.
Scattering of light. Scattering in a turbid medium, Tyndall effect, Rayleigh law, nephelometry. Molecular scattering, Raman spectroscopy.
Polarization of light. Unpolarized and polarized light. Malus' law. Fully polarized light, Brewster's law, birefringence, polarizers. Optical activity.
Ultraviolet and infrared radiation. Sun radiation. Fields and zones. Properties. Sources and detectors. Medical application. Thermography. Ozone hole. "Greenhouse effect".

Theme 12. Lenses, Human eye - 2 hours

Lenses. Type of lenses, optical systems. Basic elements of lens, lens aberrations, astigmatism. Cylindrical lenses, optical prisms.
Human eye. Human eye as an optical system. Defects in the optical system of the eye, corrections.

Theme 13. Light microscope - 1 hour

Microscope device. Magnifying power. Resolution of a microscope. Immersion objectives. Different microscope methods.

VI. QUANTUM PHYSICS - 5 hours

Theme 14. Electron microscope - 1 hour

Basic principles, De Broglie's wave, resolution of electron microscope. Transmission electron microscope. Scanning electron microscope.

Theme 15. Outer and inner photoelectric effect - 1 hour

Photoelectric emission, laws. Einstein's equation. Photo conductivity and photo electromotive force. Photoelectric transducers, applications.

Theme 16. Optical atomic and molecular spectra - 1 hour

Energy levels of atoms and quantum numbers. Different types of transitions in atoms. Atomic spectral analysis – spectral apparatuses, emission spectroscopy, absorption spectroscopy and fluorescence analysis. Energy levels and transitions in molecules. Spectrophotometry.

Theme 17. Luminescence - 1 hour

Types of luminescence, laws of photoluminescence. Photoluminescence transitions in diatomic molecules . Molecular fluorescence analysis.

Theme 18. Lasers - 1 hour

Normal energy level population and inverted population. The elements of a Laser. Principle of working. Different kinds of Lasers. Laser light. Some applications.

VII. ATOMIC AND NUCLEAR PHYSICS - 10 hours

Theme 19. Nuclear Physics - 5 hours

Nuclear magnetic resonance. Content, charge, mass and spin of a nucleus. Magnetic momentums of nucleons and nuclei. Nuclear magnetic resonance. Nuclear magnetic resonance imaging.

X-rays. Mechanism of X-ray tubes. Bremsstrahlung and characteristic X-rays. Intensity and spectra of Roentgen rays. Main properties. X-ray spectroscopy.

Radioactivity. α-radioactive decay. β-radioactive decay. Electron capture (K-capture). Gamma-rays. Isomeric transition. Mössbauer effect.

Radioactive decay. Radioactive decay's law. Half lifetime. Neutron-activation analysis. Radiopharmaceuticals. Effective period of half clearance.

Interaction of photon ionizing radiation with matter.Photoelectric absorption. Compton effect. Creation of electron-positron pair. Exponential absorption law.

Theme 20. Ionizing radiation - 5 hours

Interaction of charged particles with matter. Dosimetry quantities and units: absorbed dose , exposition, equivalent dose, effective dose.

Dosimetry of ionizing radiation. Dosimeters and radiometers. Ionization chamber. Photographic emulsions. Proportional counters. Semiconductor detectors. Scintillation detector. Thermo luminescent dosimeters.

X-rays diagnosis and therapy. Principles of Roentgen diagnosis, different kind of methods. X-rays image intensifier tube. Roentgen- rays therapy. X-rays protection.

Radionuclide diagnosis. Scintilators as transducer. Linear scintillation diagnostic. Gamma camera. SPECT. PET.

Protection from ionizing radiation. Natural and artificial sources of ionizing radiation. Biologic effects of ionizing radiation – outer and internal radiation, radiation injuries. Principles of radiation protections, different types of protection.

LITERATURE FOR PREPARATION:

1. Lectures – reprints of each one given to the students.

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3. D. Halliday , R. Resnick, J. Walker. Fundamentals of Physics Extended, 2007, 1328 pp.

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FACULTY OF DENTAL MEDECINE

Department of Medical Physics and Biophysics

THEMATIC CALENDAR SCHEDULE
of the LECTURES ON MEDICAL PHYSICS
for students of dental medicine
during the first (winter) semester of the first academic year

Lectures - 45 hours,
Course Duration: one semester, the first semester
(Odd weeks - 2 hours, even weeks - 4 hours)

Week No.	Subject	Hours
1st	**Basic principles and quantities of mechanics** Velocity, acceleration, forces, impulse, laws of motion, linear motion, Newton's laws, work, kinetic energy, potential energy, conservation of energy, different kind of movement, pressure, density. Atmospheric pressure, dependence of atmospheric pressure from the altitude, influence of atmospheric pressure upon human organism. **Circular motion** Angular momentum, uniform circular motion, non-uniform circular motion, centripetal acceleration, centripetal force, angular velocity, moment of inertia, angular momentum. Influence of inertia forces upon human organism.	**2 hours**
2nd	**Motion of ideal fluids** Basic concepts and laws – continuity of the flow, Bernoulli's equation. Medical applications. Laminar and turbulent motion. Blood pressure measurement. **Motion of real fluids** Newton's law for inner friction. Poeuaseu's law, viscosimetry. Non-Newton's behavior and micro rheological processes. **Separation of the phases in liquid heterogeneous systems** Sedimentation and centrifugation. Velocity of sedimentation force of centrifugation, Centrifuges – device, different types. Inertial forces effect upon human organism. **Sound** Mechanical oscillations and waves – basic quantities and equations. Principles of Extracorporeal lithotripsy. Velocity of the sound, Doppler's effect, physical characteristics of the sound.	**2 hours** **2 hours**
3rd	**Psychophysical characteristic of sound** Field of hearing. Psychophysical parameters of sound. Vocal apparatus of human. Noise protection. Acoustic methods for diagnostics. Infrasound. **Ultrasound** Producing, general characteristics and effect of the ultrasound. Principles of ultrasound diagnostics, Doppler sonography. Medical application of ultrasound, drug ultraphonophorhesis.	**2 hours**

4th	**Structure of liquids** Surface tension. Molecular pressure. Phenomenon on boundary between two different phases – menisci, capillarity. Gas embolisms. Trickling. **Structure of solids** Amorphous solids, crystalline solids, liquid crystals. Robert Hooke law. Strength and hardness. **Temperature and heat** Zeroth Law of Thermodynamics. Temperature Scales. Linear Thermal Expansion. Volume Thermal Expansion. Phase Change of Water. Specific Heat Capacity. Calorimetry. **The first law of thermodynamics** Statements of the First Law. Macroscopic state of a system. Some common thermodynamic processes: isochoric process (isovolumetric process), isobaric process, isothermal process, adiabatic process. quasi-static process, thermodynamic equilibrium, cyclic process, reversible process and irreversible process.	**2 hours** **2 hours**
5th	**Second law of thermodynamics** A statement of the Second Law. Heat Engines and the Carnot Cycle. the efficiency. Refrigerators, Air Conditioners. Order, Disorder, and Entropy. The third law of thermodynamics. **Thermal exchange by radiation and absorption** Basic conceptions and quantities of thermal radiation. Kirchoff's law, Stefan Boltzman's law, Wien's law. Thermostats, thermo regulators, sterilizers.	**2 hours**
6th	**Electric field** Magnitude of electric field. Electric potential. Dipolar molecules in electric pole. Parallel plate capacitor. Electric capacity of conductors. **Electric conductivity of solids** Zone theory of electric conductivity. Electric conductivity of metals. Conductivity of intrinsic semiconductors; conductivity of semiconductors with impurities. Thermistors and bolometers. **Electric current** Electric Current. Resistance and Ohm's Law. Resistors in Series and Parallel. Ammeters and Voltmeters. Alternating Current. Capacitors in AC Circuits. RC Circuits. Inductors in AC Circuits. RLC Circuits. Resonance in Electrical Circuits. Electrical Safety. **Magnetic field** Magnitude of magnetic field, magnetic field lines. Motion of a Charged Particle in a Uniform Magnetic Field. Lorentz force. Mass Spectrometer. Cyclotron	**2 hours** **2 hours**
7th	**Magnetic properties of a matter** Dia-magnetics, para-magnetics and ferro-magnetics. Hysteresis. Mechanical moment and magnetic moment of an electron as well of an atom. Electron paramagnetic resonance, applications. **Physical base of electric diagnostics** Electrography, heart as an electric dipole. Electric stimulation – electric stimulation of tissues, diagnostic parameters, pulses of different shape, applications. Transducers of non-electrical quantities.	**2 hours**
	Physical base of electric therapy	

8th	Therapy with direct electric current. Therapy with pulse electric current with low frequency. Defibrillators. Pacemakers. Electric therapy with alternating current having high frequency. Electromagnetic field and its effect on a man, critical organs. **Electromagnetic field** Magnetic flux. Electromagnetic induction, mutual inductance, self-inductance. Electromagnetic(EM) waves, Maxwell's equations. Speed of EM waves. EM spectrum. **Reflection and refraction of light** Photometric quantities and units. Spectral sensitivity of human eye. Reflection and refraction of light, laws. Ophthalmoscope. Total internal reflection, fiber optics, endoscopy. Refractometry. **Dispersion and absorption of light** Normal and abnormal dispersion. Absorption of light, Lambert-Beer's law. Colorimetry and photometry of cells.	**2 hours** **2 hours**
9th	**Scattering of light** Scattering in a turbid medium, Tyndall effect, Rayleigh law, nephelometry. Molecular scattering, Raman spectroscopy. **Polarization of light** Unpolarized and polarized light. Malus' law. Fully polarized light, Brewster's law, birefringence, polarizers. Optical activity.	**2 hours**
10th	**Ultraviolet and infrared radiation** Sun radiation. Fields and zones. Properties. Sources and detectors. Medical application. Thermography. Ozone hole. "Greenhouse effect". **Lenses** Type of lenses, optical systems. Basic elements of lens, lens aberrations, astigmatism. Cylindrical lenses, optical prisms. **Human eye** Human eye as an optical system. Defects in the optical system of the eye, corrections. **Light microscope** Microscope device. Magnifying power. Resolution of a microscope. Immersion objectives. Different microscope methods.	**2 hours** **2 hours**
11th	**Electron microscope** Basic principles, De Broglie's wave, resolution of electron microscope. Transmission electron microscope. Scanning electron microscope. **Outer and inner photoelectric effect** Photoelectric emission, laws. Einstein's equation. Photo conductivity and photo electromotive force. Photoelectric transducers, applications.	**2 hours**
	Optical atomic and molecular spectra Energy levels of atoms and quantum numbers. Different types of transitions in atoms. Atomic spectral analysis – spectral apparatuses, emission spectroscopy, absorption spectroscopy and fluorescence analysis. Energy levels and transitions in molecules.	

12th	Spectrophotometry. **Luminescence** Types of luminescence, laws of photoluminescence. Photoluminescence transitions in diatomic molecules . Molecular fluorescence analysis. **Lasers** Normal energy level population and inverted population. The elements of a Laser. Principle of working. Different kinds of Lasers. Laser light. Some applications. **Nuclear magnetic resonance** Content, charge, mass and spin of a nucleus. Magnetic momentums of nucleons and nuclei. Nuclear magnetic resonance. Nuclear magnetic resonance imaging.	**2 hours** **2 hours**
13th	**X-rays** Mechanism of X-ray tubes. Bremsstrahlung and characteristic X-rays. Intensity and spectra of Roentgen rays. Main properties. X-ray spectroscopy. **Radioactivity** α-radioactive decay. β-radioactive decay. Electron capture (K-capture). Gamma-rays. Isomeric transition. Mössbauer effect.	**2 hours**
14th	**Radioactive decay** Radioactive decay's law. Half lifetime. Neutron-activation analysis. Radiopharmaceuticals. Effective period of half clearance. **Interaction of photon ionizing radiation with matter** Photoelectric absorption. Compton effect. Creation of electron-positron pair. Exponential absorption law. **Interaction of charged particles with matter** Dosimetry quantities and units: absorbed dose , exposition, equivalent dose, effective dose. **Dosimetry of ionizing radiation** Dosimeters and radiometers. Ionization chamber. Photographic emulsions. Proportional counters. Semiconductor detectors. Scintillation detector. Thermo luminescent dosimeters.	**2 hours** **2 hours**
15th	**X-rays diagnosis and therapy** Principles of Roentgen diagnosis, different kind of methods. X-rays image intensifier tube. Roentgen- rays therapy. X-rays protection. **Radionuclide diagnosis** Scintilators as transducer. Linear scintillation diagnostic. Gamma camera. SPECT. PET. **Protection from ionizing radiation** Natural and artificial sources of ionizing radiation. Biologic effects of ionizing radiation – outer and internal radiation, radiation injuries. Principles of radiation protections, different types of protection.	**3 hours**

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THEMATIC CALENDAR SCHEDULE
of the LABORATORY PRACTICE IN MEDICAL PHYSICS
for students of dental medicine
during the first (winter) semester of the first academic year

LABORATORY PRATICE - 30 hours,
Course Duration: one semester, the first semester
(Every week 2 hours)

Week No.	Subject	Hours
1st	**Seminar: Measurements of physical quantities and introduction to the theory of errors in measurement. International system units SI. Base,derived and non SI units.**	2 hours
2nd	**Determination of dynamic viscosity of liquids.** *Seminar Part:* Newton's law of internal friction. Poiseuille's Law. Viscosimetry. None Newton microrheological behavior and processes.	2 hours
3rd	**Measurement of auditory acuity via an audiometer.** *Seminar Part:* District of hearing, Psychophysics parameters and sound parameters of the hearing. Noise protection. Principles of acoustic diagnostics. Measurement of spectral characteristics of the ear in hearing threshold.	2 hours
4th	**Determination of surface tension of liquids.** *Seminar Part:* Surface tension, molecular pressure. Phenomena of phase Borders - meniscus, capillary. Gas embolism. Dropping method. thermodynamic equilibrium, cyclic process, reversible process and irreversible process.	2 hours
5th	**Determination of modulus of elasticity of bone.** *Seminar Part*: amorphous, crystalline and liquid crystal state. Mechanical deformation law of Hooke. Strength and hardness of materials, methods for determining, Identify the module of linear deformation of bone.	2 hours
6th	**Photometric values and measurements.** *Seminar Part*: Energetic and light photometric quantities and units. Spectral sensitivity of human eye. Lambert's Law. Comparing the intensities of light sources and determine the sensitivity of selenium photocell.	2 hours
7th	**Determination of refractive index of liquids by refractometer.** *Seminar Part:* Laws of reflection and refraction, ophthalmoscopy. Total internal reflection. Refractometers, wire optics endoscopy	2 hours
8th	**Photocolorimetric determination of the concentration.** *Seminar Part:* Normal and anomalous dispersion. Absorption of light – Law of Bouguer-Lambert-Beer. Photocolorimetry and citophotometry.	2 hours
9th	**Determination of optical lenses and prisms using dioptrometer.** *Seminar Part:* Types of optical lenses and systems. Main elements and disadvantages of	

	spherical lenses. Cylindrical lenses and optical prisms. Eye as an optical system of optical correcting its shortcomings.	**2 hours**
10th	**Observation and analysis of atomic and molecular spectra.** *Seminar Part:* Energy states of atoms and quantum numbers. Types of transitions and atomic spectra. Atomic spectral analysis - spectral apparatus, emission, absorption and fluorescence analysis. Assignment: Observation and analysis of atomic and molecular spectra.	**2 hours**
11th	**A relative method for determination of radioactivity.** *Seminar Part:* Radioactivity, radionuclides. Alpha-and beta-nuclear transformations, energy spectra. Gamma radiation spectra, isomeric transition. Activity of radioactive source. Law of radioactive conversion half-life of radionuclide. Radiopharmaceutical species use. Radiometric and radio-immunoassay. Neutron-activation analysis.	**2 hours**
12th	**Determination of the common linear coefficient for weakening of matter for gamma rays.** *Seminar Part:* Photoelectric absorption, scattering komptanovo, formation of electron-positron pairs - mechanism and linear coefficients of the processes. Act to reduce the intensity. Determination of jacketed linear coefficient of attenuation of the substance of gamma rays.	**2 hours**
13th	**Main quantities in medical radiology.** *Seminar Part:* Transmitted energy, absorbed dose, kerma, exposure, equivalent and effective dose, power of exposure and dose. Determination of the equivalent dose received by the radioactive source and the natural radiation background in the power of exposure.	**2 hours**
14th	**Laser. Investigation of the general properties of laser radiation.** *Seminar Part:* Normal and inverse population of energy levels. Main parts and principle operation of laser. Types of lasers. Properties of laser radiation. Applications in dentistry. Determination of monochromaticity, divergence and coherence of laser radiation genegated by He-Ne laser.	**2 hours**
15th	**Test examination on practical exercises and a semester validation.**	**2 hours**

SYNOPSIS FOR THE FINAL EXAM IN MEDICAL PHYSICS
FOR STUDENTS OF DENTAL MEDICINE

I. MECHANICS

1. BASIC PRINCIPLES AND QUANTITIES OF MECHANICS

Velocity, acceleration, forces, impulse, laws of motion, linear motion, Newton's laws, work, kinetic energy, potential energy, conservation of energy, different kind of movement, pressure, density. Atmospheric pressure, dependence of atmospheric pressure from the altitude, influence of atmospheric pressure upon human organism.

2. CIRCULAR MOTION

Angular momentum, uniform circular motion, non-uniform circular motion, centripetal acceleration, centripetal force, angular velocity, moment of inertia, angular momentum. Influence of inertia forces upon human organism.

3. MOTION OF IDEAL FLUIDS

Basic concepts and laws – continuity of the flow, Bernoulli's equation. Medical applications. Laminar and turbulent motion. Blood pressure measurement.

4. MOTION OF REAL FLUIDS

Newton's law for inner friction. Poeuaseu's law, viscosimetry. Non-Newton's behavior and micro rheological processes.

5. SEPARATION OF THE PHASES IN LIQUID HETEROGENEOUS SYSTEMS

Sedimentation and centrifugation. Velocity of sedimentation force of centrifugation, Centrifuges – device, different types. Inertial forces effect upon human organism.

II. AQUSTICS

6. SOUND

Mechanical oscillations and waves – basic quantities and equations. Principles of Extracorporeal lithotripsy. Velocity of the sound, Doppler's effect, physical characteristics of the sound.

7. PSYCHOPHYSICAL CHARACTERISTIC OF SOUND

Field of hearing. Psychophysical parameters of sound. Vocal apparatus of human. Noise protection. Acoustic methods for diagnostics. Infrasound.

8. ULTRASOUND

Producing, general characteristics and effect of the ultrasound. Principles of ultrasound diagnostics, Doppler sonography. Medical application of ultrasound, drug ultraphonophorhesis.

III. MOLECULAR PHYSICS. THERMODYNAMICS.

9. STRUCTURE OF LIQUIDS

Surface tension. Molecular pressure. Phenomenon on boundary between two different phases – menisci, capillarity. Gas embolisms. Trickling.

10. STRUCTURE OF SOLIDS

Amorphous solids, crystalline solids, liquid crystals. Robert Hooke law. Strength and hardness.

11. TEMPERATURE AND HEAT

Zeroth Law of Thermodynamics. Temperature Scales. Linear Thermal Expansion. Volume Thermal Expansion. Phase Change of Water. Specific Heat Capacity. Calorimetry.

12. THE FIRST LAW OF THERMODYNAMICS

Statements of the First Law. Macroscopic state of a system. Some common thermodynamic processes: isochoric process (isovolumetric process), isobaric process, isothermal process, adiabatic process. quasi-static process, thermodynamic equilibrium, cyclic process, reversible process and irreversible process.

13. SECOND LAW OF THERMODYNAMICS

A statement of the Second Law. Heat Engines and the Carnot Cycle. the efficiency. Refrigerators, Air Conditioners. Order, Disorder, and Entropy. The third law of thermodynamics.

14. THERMAL EXCHANGE BY RADIATION AND ABSORPTION

Basic conceptions and quantities of thermal radiation. Kirchoff's law, Stefan Boltzman's law, Wien's law. Thermostats, thermo regulators, sterilizers.

IV. ELECTRICITY AND MAGNETISM.

15. ELECTRIC FIELD

Magnitude of electric field. Electric potential. Dipolar molecules in electric pole. Parallel plate capacitor. Electric capacity of conductors.

16. ELECTRIC CONDUCTIVITY OF SOLIDS

Zone theory of electric conductivity. Electric conductivity of metals. Conductivity of intrinsic semiconductors; conductivity of semiconductors with impurities. Thermistors and bolometers.

17. ELECTRIC CURRENT

Electric Current. Resistance and Ohm's Law. Resistors in Series and Parallel. Ammeters and Voltmeters. Alternating Current. Capacitors in AC Circuits. RC Circuits. Inductors in AC Circuits. RLC Circuits. Resonance in Electrical Circuits. Electrical Safety.

18. MAGNETIC FIELD

Magnitude of magnetic field, magnetic field lines. Motion of a Charged Particle in a Uniform Magnetic Field. Lorentz force. Mass Spectrometer. Cyclotron

19. MAGNETIC PROPERTIES OF A MATTER

Dia-magnetics, para-magnetics and ferro-magnetics. Hysteresis. Mechanical moment and magnetic moment of an electron as well of an atom. Electron paramagnetic resonance, applications.

20. PHYSICAL BASE OF ELECTRIC DIAGNOSTICS

Electrography, heart as an electric dipole. Electric stimulation – electric stimulation of tissues, diagnostic parameters, pulses of different shape, applications. Transducers of non-electrical quantities.

21. PHYSICAL BASE OF ELECTRIC THERAPY

Therapy with direct electric current. Therapy with pulse electric current with low frequency. Defibrillators. Pacemakers. Electric therapy with alternating current having high frequency. Electromagnetic field and its effect on a man, critical organs.

22. ELECTROMAGNETIC FIELD

Magnetic flux. Electromagnetic induction, mutual inductance, self-inductance. Electromagnetic(EM) waves, Maxwell's equations. Speed of EM waves. EM spectrum.

V. OPTICS

23. REFLECTION AND REFRACTION OF LIGHT

Photometric quantities and units. Spectral sensitivity of human eye. Reflection and refraction of light, laws. Ophthalmoscope. Total internal reflection, fiber optics, endoscopy. Refractometry.

24. DISPERSION AND ABSORPTION OF LIGHT

Normal and abnormal dispersion. Absorption of light, Lambert-Beer's law. Colorimetry and photometry of cells.

25. SCATTERING OF LIGHT

Scattering in a turbid medium, Tyndall effect, Rayleigh law, nephelometry. Molecular scattering, Raman spectroscopy.

26. POLARIZATION OF LIGHT

Unpolarized and polarized light. Malus' law. Fully polarized light, Brewster's law, birefringence, polarizers. Optical activity.

27. ULTRAVIOLET AND INFRARED RADIATION

Sun radiation. Fields and zones. Properties. Sources and detectors. Medical application. Thermography. Ozone hole. "Greenhouse effect".

28. LENSES

Type of lenses, optical systems. Basic elements of lens, lens aberrations, astigmatism. Cylindrical lenses, optical prisms.

29. HUMAN EYE

Human eye as an optical system. Defects in the optical system of the eye, corrections.

30. LIGHT MICROSCOPE

Microscope device. Magnifying power. Resolution of a microscope. Immersion objectives. Different microscope methods.

VI. QUANTUM PHYSICS

31. ELECTRON MICROSCOPE

Basic principles, De Broglie's wave, resolution of electron microscope. Transmission electron microscope. Scanning electron microscope.

32. OUTER AND INNER PHOTOELECTRIC EFFECT

Photoelectric emission, laws. Einstein's equation. Photo conductivity and photo electromotive force. Photoelectric transducers, applications.

33. OPTICAL ATOMIC AND MOLECULAR SPECTRA

Energy levels of atoms and quantum numbers. Different types of transitions in atoms. Atomic spectral analysis – spectral apparatuses, emission spectroscopy, absorption spectroscopy and fluorescence analysis. Energy levels and transitions in molecules. Spectrophotometry.

34. LUMINESCENCE

Types of luminescence, laws of photoluminescence. Photoluminescence transitions in diatomic molecules . Molecular fluorescence analysis.

35. LASERS

Normal energy level population and inverted population. The elements of a Laser. Principle of working. Different kinds of Lasers. Laser light. Some applications.

VII. ATOMIC AND NUCLEAR PHYSICS.

36. NUCLEAR MAGNETIC RESONANCE

Content, charge, mass and spin of a nucleus. Magnetic momentums of nucleons and nuclei. Nuclear magnetic resonance. Nuclear magnetic resonance imaging.

37. X-RAYS

Mechanism of X-ray tubes. Bremsstrahlung and characteristic X-rays. Intensity and spectra of Roentgen rays. Main properties. X-ray spectroscopy.

38. RADIOACTIVITY

α-radioactive decay. β-radioactive decay. Electron capture (K-capture). Gamma-rays. Isomeric transition. Mössbauer effect.

39. RADIOACTIVE DECAY

Radioactive decay's law. Half lifetime. Neutron-activation analysis. Radiopharmaceuticals. Effective period of half clearance.

40.INTERACTION OF PHOTON IONIZING RADIATION WITH MATTER Photoelectric absorption. Compton effect. Creation of electron-positron pair. Exponential absorption law.

41. INTERACTION OF CHARGED PARTICLES WITH MATTER

Dosimetry quantities and units: absorbed dose , exposition, equivalent dose, effective dose.

42. DOSIMETRY OF IONIZING RADIATION

Dosimeters and radiometers. Ionization chamber. Photographic emulsions. Proportional counters. Semiconductor detectors. Scintillation detector. Thermo luminescent dosimeters.

43. X-RAYS DIAGNOSIS AND THERAPY

Principles of Roentgen diagnosis, different kind of methods. X-rays image intensifier tube. Roentgen-rays therapy. X-rays protection.

44. RADIONUCLIDE DIAGNOSIS

Scintilators as transducer. Linear scintillation diagnostic. Gamma camera. SPECT. PET.

45. PROTECTION FROM IONIZING RADIATION

Natural and artificial sources of ionizing radiation. Biologic effects of ionizing radiation – outer and internal radiation, radiation injuries. Principles of radiation protections, different types of protection.

LITERATURE FOR PREPARATION:

1. Lectures – reprints of each one given to the students.
2. D. Ewen, R. Nelson, N. Schurter, E. Gundersen. Applied Physics, 2004, 768pp.
3. D. Halliday , R. Resnick, J. Walker. Fundamentals of Physics Extended, 2007, 1328 pp.