MEDICAL UNIVERSITY - PLEVEN
FACULTY OF MEDICINE

DIVISION OF PHYSICS AND BIOPHYSICS

PROGRAM OF STUDY

IN

MEDICAL PHYSICS

ENGLISH MEDIUM COURSE OF TRAINING
SPECIALTY OF MEDICINE

ACADEMIC DEGREE **MASTER**

PROFESSIONAL QUALIFICATION **DOCTOR OF MEDICINE**

Developed by:	**Approved by:**	**Endorsed by:**	Copy No 03
Prof. M. Alexandrova, DSc	Prof. A. Asparuhov, DSc Dean of Faculty of Medicine	Faculty Council	
02.02.2016 ..... /date, signature/	..... /date, signature/	..... /date/	Valid from:

According to the unified state requirements: compulsory

According to the curriculum: compulsory

Academic year I, semester I

Total number of hours: 90 – lectures 45 and practical exercises 45

Total credits: 6

Lecturer:

- **Prof. Margarita Alexandrova**, DSc, PhD, Master in Physics, specialties: Biophysics; Solid state electronics and optoelectronics; room 239, tel.: 064 884 162; E- mail: margalexandrova@yahoo.com

Assistant professors:

- **Victoria Varbanova**, Master in Physics, specialties: Optics and spectroscopy, Teacher in Physics and Astronomy; room 234, tel. 064 884 163; E- mail: viki_varbanova@abv.bg
- **Veselin Ganev**, PhD, Master in Chemistry; specialty Technology of organic synthesis and rubber; room 241, tel. 064 884 173; E- mail: vesselin.ganev@gmail.com
- **Daniela Uzunova**, Master in Physics, specialty *Laser techniques and technologies*, Teacher in Physics*;* room 234, tel. 884 163; E- mail: *douzounova@yahoo.com*

AIM AND TASKS OF EDUCATION

The aim of Medical Physics course is to deepen the specific scientific knowledge of medical students in the field of applications of physics to medicine and medical instrumentation.

This programme is intended to:

- provide education and training of high quality in Medical Physics;
- help students to understand the physical mechanisms underlying biological processes;
- provide students with a knowledge on the application of physical devices for diagnosis and treatment of diseases.

FORMS OF EDUCATION:

- Lectures
- Practical exercises

METHODS OF EDUCATION:

- Lecturing
- Practicing
- Classroom discussion
- Extracurricular activities

THEMATIC PLAN OF LECTURES

No	Topic	Acad. h
1	MEDICAL PHYSICS. MEASUREMENT AND THE SCIENTIFIC METHOD OF INVESTIGATION The role of the experiment. Measurement. Accuracy and significant digits. Scientific notation. The conversion of units	3
2	FLUID STATICS AND DYNAMICS The states of matter. The definition of pressure. Pressure in liquids. Distribution of pressure in a static liquid. Transmission of pressure: Pascal's principle. Clinical applications of Pascal's principle. Buoyant force and Archimedes principle. Pressure in flowing fluids	3
3	PRESSURE AND THE CIRCULATORY SYSTEM Types of pumps. The heart as a force pump. The circulatory system. The energy supplied by the heart. The variations of the blood pressure. The measurement of blood pressure	3
4	MOLECULAR PHENOMENA RELATED TO BIOLOGICAL PROCESSES The kinetic energy of molecules. Diffusion. Osmosis. Dialysis. Transport across living membranes. Cohesion and adhesion. Surface tension and respiration. Capillary action. Viscosity. Adsorption and adsorption	3
5	INTERNAL ENERGY, HEAT AND TEMPERATURE Internal energy. The distinction between internal energy and temperature. Temperature scales. Heat and the first law of thermodynamics. Thermal expansion. Methods for temperature measurement. Internal energy and specific heat. Heat of combustion: the dietary calorie. The mechanical equivalent of heat	3
6	THE EFFECTS OF HEAT Changes of phase. Applications of phase changes. Evaporation and vapor pressure. Relative humidity. Heat transfer. Physiological applications of heat transfer	3
7	INTRODUCTION TO ELECTRICITY AND MAGNETISM The electrical nature of matter. The behavior of electric charges. The flow of electric charge. Electric fields and voltages. Cathode ray tubes. The oscilloscope. Magnets and magnetic fields. Electromagnets. The interaction between electricity and magnetism	3
8	ELECTRICAL AND ELECTRONIC INSTRUMENTS Sensing elements for physiological measurements. Amplifiers. Display devices. The defibrillator. Electrocautery and electrosurgery	3
9	BIOELECTRICITY The living cell as an electric source. The electrocardiogram. The electroencephalogram. Other bioelectric measurements. The electronic pacemaker	3
10	ELASTICITY AND WAVE MOTION Elasticity. Periodic motion and resonance. Traveling waves. Wave properties of sound and light. Energy in waves. Interference and standing waves. The Doppler effect. Ultrasonic sound	3
11	THE PHYSICS OF HEARING The mechanism of the ear. The range and sensitivity of human hearing. The decibel scale. The distinction between loudness and intensity. Hearing tests. The measurement of environmental sound	3
12	THE PHYSICS OF VISION Refraction and lenses. Image formation by the eye. Common vision defects. Simple optical instruments. Color vision	3

13	LIGHT AND MODERN PHYSICS – part 1 The electromagnetic spectrum. The quantum theory of light. Matter waves: The electron microscope. Quantum theory of the atom. The interaction of electromagnetic waves with matter	3
14	LIGHT AND MODERN PHYSICS – part 2 Clinical applications of electromagnetic waves. Medical imaging with CT and NMR scans. The laser and its applications	3
15	NUCLEAR RADIATION A scale model of the atom. The nature of the nucleus. The three basic types of radioactivity. Radioactive decay and half-life. Medical radioisotopes. The detection of radiation. Effects of ionizing radiation on biologic material. Measurement of radiation exposure. Radiation therapy. Nuclear energy	3
	TOTAL	45

LECTURES - THESES

1. MEDICAL PHYSICS. MEASUREMENT AND THE SCIENTIFIC METHOD OF INVESTIGATION

1.1. The role of the experiment.
1.2. Measurement.
  1.2.1. SI system
  1.2.2. Base and derived units
1.3. Accuracy and significant digits.
1.4. Scientific notation. Order of magnitude.
1.5. The conversion of units

2. FLUID STATICS AND DYNAMICS

2.1. The states of matter.
2.2. The definition of pressure. The difference between force and pressure
2.3. Pressure in liquids.
  2.3.1. Weight
  2.3.2. Hydrostatic pressure
2.4. Distribution of pressure in a static liquid.
2.5. Transmission of pressure: Pascal's principle.
  2.5.1. I.V. apparatus
  2.5.2. The hydraulic press
2.6. Clinical applications of Pascal's principle.
  2.6.1. The usage of water mattresses for chronically ill patients
  2.6.2. The cerebrospinal fluid
  2.6.3. The role of fluid surrounding the amniotic sac
  2.6.4. The role of the enclosed fluid in the eye
  2.6.5. The effects of collected fluid in pericardial and pleural cavities
2.7. Buoyant force and Archimedes principle.
  2.7.1. Buoyancy
  2.7.2. Specific gravity of a liquid. The urinometer
  2.7.3. Method for the determination of the volume of an irregularly shaped objects
2.8. Pressure in flowing fluids
  2.8.1. Pressure gradient
  2.8.2. Poiseuille's law. Resistance to flow

3. PRESSURE AND THE CIRCULATORY SYSTEM

3.1.1. Types of pumps. Lift pump. Force pump

3.2. The heart as a force pump

3.3. The circulatory system

3.4. The control of volume flow rate

3.4.1. Arterioles – the resistance vessels

3.4.2. The control of the distribution of blood by kidneys and digestive tract

3.5. The applicability of Poiseuille's law

3.6. Changes in blood speed during circulation

3.7. Wall Tension and Laplace's law

3.7.1. For cylindrical membrane

3.7.2. For spherical membrane

3.8. The energy supplied by the heart.

3.8.1. Potential energy per unit volume

3.8.2. Kinetic energy per unit volume

3.8.3. The pressure power of the heart

3.9. The variations of the blood pressure.

3.10. The measurement of blood pressure

4. MOLECULAR PHENOMENA RELATED TO BIOLOGICAL PROCESSES

4.1. The kinetic energy of molecules.

4.2. Diffusion.

4.2.1. Concentration gradient

4.2.2. Fick's law

4.3. Osmosis.

4.3.1. Osmotic pressure

4.3.2. Isotonic, hypertonic and hypotonic solutions

4.4. Dialysis. The function of a kidney nephron.

4.5. Transport across living membranes. Molecular transfer in the capillary system

4.6. Cohesion and adhesion. Capillarity. Surface tension. Surface tension and respiration. Capillary action.

4.7. Viscosity. Newton's law. Velocity gradient

4.8. Adsorption and adsorption

5. INTERNAL ENERGY, HEAT, AND TEMPERATURE

5.1. Internal energy. Random and ordered motion

5.2. The distinction between internal energy and temperature. Thermal equilibrium

5.3. Temperature scales.

5.4. Heat and the first law of thermodynamics. Isothermal expansion of a gas

5.5. Thermal expansion. Fractional expansion. Linear, area and volume expansion

5.6. Methods for temperature measurement

5.6.1. Liquids expansion thermometer

5.6.2. Bimetallic strip thermometer

5.6.3. Constant volume gas thermometer

5.7. Internal energy and specific heat.

5.8. Heat of combustion: the dietary calorie. The mechanical equivalent of heat

6. THE EFFECTS OF HEAT

6.1. Changes of phase.

6.1.1. Latent heat of fusion and latent heat of melting

6.1.2. Latent heat of vaporization

6.1.3. Phase diagrams (temperature-time relationships)

6.2. Applications of phase changes

6.2.1. Refregeration

6.2.2. Cooling by perspiration

6.2.3. Application of the melting transition

6.3. Evaporation and vapor pressure. Saturation vapor pressure and saturation vapor density. Boiling point.

6.4. Relative humidity

6.5. Heat transfer

6.5.1. Conduction. Fourier's law

6.5.2. Convection

6.5.3. Radiation

6.6. Physiological applications of heat transfer

7. INTRODUCTION TO ELECTRICITY AND MAGNETISM

7.1. The electrical nature of matter.

7.2. The behavior of electric charges. Coulomb's law

7.3. The flow of electric charge. Conductors. Insulators and semiconductors. The electroscope. The electric current

7.4. Electric fields and voltages.

7.4.1. Test charge. Lines of force

7.4.2. Capacitor

7.5. Cathode ray tubes. The oscilloscope

7.6. Magnets and magnetic fields. Para-, dia and ferromagnetic.

7.7. Electromagnets. The interaction between electricity and magnetism. The force exerted upon an electric charge by a magnetic field. Magnetic flux. Faraday's law

8. ELECTRICAL AND ELECTRONIC INSTRUMENTS

8.1. Sensing elements for physiological measurements

8.1.1. Thermocouples

8.1.2. The electrical resistance thermometer

8.1.3. The thermistor

8.1.4. Pressure transducers

8.1.5. The oximeter

8.1.6. Electrodes for pH, PCO_2 and PO_2

8.2. Amplifiers

8.2.1. Triodes

8.2.2. Transistors

8.3. Display devices

8.3.1. The oscilloscope

8.3.2. Meters and chart recorders

8.3.3. Digital displays

8.4. The defibrillator. Electrocautery and electrosurgery

9. BIOELECTRICITY

9.1. The living cell as an electric source.

9.1.1. Rest potential

9.1.2. Action potential

9.2. The electrocardiogram. The triangle of Einthoven

9.3. The electroencephalogram. Other bioelectric measurements. The electronic pacemaker

10. ELASTICITY AND WAVE MOTION

10.1. Elasticity. Hooke's law
- 10.1.1. Periodic motion and resonance. Frequency. Amplitude

10.2. Traveling waves
- 10.2.1. Transverse waves
- 10.2.2. Longitudinal waves
- 10.2.3. Wavelength

10.3. Wave properties of sound and light
- 10.3.1. Energy in waves. Intensity. Inverse square law

10.4. Interference and standing waves

10.5. The Doppler effect

10.6. Ultrasonic sound. Ultrasonic scan

11. THE PHYSICS OF HEARING

11.1. The mechanism of the ear

11.2. The range and sensitivity of human hearing. The area of hearing

11.3. The relative intensity. The decibel scale

11.4. The distinction between loudness and intensity. Equal loudness curves

11.5. Hearing tests. Audiometery. The measurement of environmental sound

12. THE PHYSICS OF VISION

12.1. Refraction and lenses
- 12.1.1. Refractive index
- 12.1.2. Snell's law
- 12.1.3. Lens power

12.2. Image formation by lens

12.3. Image formation by the eye

12.4. Common vision defects
- 12.4.1. Myopia (nearsightedness)
- 12.4.2. Hyperopia (farsightedness)

12.5. Simple optical instruments
- 12.5.1. The simple magnifier
- 12.5.2. The compound microscope
- 12.5.3. The ophthalmoscope
- 12.5.4. Fiber optics

12.6. Color vision
- 12.6.1. Scotopic vision (night vision, rods only)
- 12.6.2. Photopic vision (bright illumination)

13. LIGHT AND MODERN PHYSICS – part 1

13.1. The electromagnetic spectrum

13.2. The quantum theory of light
- 13.2.1. The energy of a photon
- 13.2.2. The photoelectric effect

13.3. Matter waves: The electron microscope
- 13.3.1. De Broglie waves
- 13.3.2. De Broglie wavelength

13.4. Quantum theory of the atom

13.5. The interaction of electromagnetic waves with matter. Excitation and absorption

14. LIGHT AND MODERN PHYSICS – part 2

14.1. Clinical applications of electromagnetic waves
14.2. Radio frequency and microwave radiation
14.3. Infrared radiation
  14.3.1. Black body
  14.3.2. Wien's displacement law
14.4. Ultraviolet radiation
14.5. X-ray radiation
  14.5.1. X-ray tube
  14.5.2. Bremsstrahlung and characteristic radiation
14.6. Medical imaging with CT and NMR scans.
14.7. The laser and its applications
  14.7.1. "Pumping" process and population inversions
  14.7.2. Stimulated emission
  14.7.3. Metastable states
  14.7.4. Laser applications in medicine
  14.7.5. Holography: three-dimensional images

15. NUCLEAR RADIATION

15.1. A scale model of the atom
15.2. The nature of the nucleus. The atomic and mass number.
  15.2.1. The three basic types of radioactivity. Alpha. Beta. Gamma
15.3. Radioactive decay and half-life
15.4. Medical radioisotopes
15.5. The detection of radiation
  15.5.1. Thermoluminescent dosimetry (TLD) crystals
  15.5.2. Ionization chambers, proportional counters, and Geiger-Muller counters
15.6. Effects of ionizing radiation on biologic material
15.7. Measurement of radiation exposure (curie, Becquerel, rad, roentgen, rem, sievert)
15.8. How to minimize your exposure – safety measures
15.9. Radiation therapy
15.10. Diagnostic use of radioisotopes
15.11. Nuclear energy
  15.11.1. Mass discrepancy
  15.11.2. Nuclear fusion and fission

THEMATIC PLAN OF PRACTICAL EXERSICES

No	TOPIC	Acad. h.
1.	Measurements and units of measure.	2
2.	Errors: classification, accuracy, theory of errors.	2
3.	Evaluation of liquids dynamic viscosity.	2
4.	Evaluation of liquids surface tension.	2
5.	Pressure. Air pressure. Blood pressure. Air humidity.	2
6.	Determination of threshold of hearing.	2

7.	Measurements with electric instruments.	2
8.	Graduating thermoelement.	2
9.	Graduating semiconductor thermometer.	2
10.	Current-voltage characteristics of biologically active point.	2
11.	Current-voltage characteristics of crystal diode.	2
12.	Frequency dependence of human skin impedance.	2
13.	Measurements with oscilloscope.	2
14.	Electrocardiography (ECG).	2
15.	Lens power of spherical lens.	2
16.	Total magnification of a compound microscope. Magnification of objective and eyepiece lens.	2
17.	Measuring microobjects by compound microscope.	2
18.	Mean diameter, mean area and diameter distribution of erythrocytes (application of statistical concepts).	2
19.	Measurement of concentration of biological liquids and pharmaceutical preparations by refractometer.	2
20.	Measurement of concentration of optically active liquids by polarimeter.	2
21.	Comparison of the intensity of two light sources. Determining the integral sensitivity of photopile.	2
22.	Revision.	2
23.	Colloquium.	2

PRACTICAL EXERSICES – THESES

1. Measurements and units of measure. To describe the metric units of measure; to explain what the seven fundamental units are; to explain how we can write derived units.

2. Errors: classification, accuracy, theory of errors. To explain the difference among gross, systematic and random errors; to calculate the accuracy of an individual direct measurement; to calculate the accuracy of a group of direct measurements; to calculate the accuracy of indirect measurements.

3. Total magnification of a compound microscope. Magnification of objective lens and eyepiece lens. To explain mechanical and optical structure of a compound microscope; to explain the terms magnification, definition, resolution, and depth of focus; to explain the purpose of oil-immersion objectives, to calculate total magnification of compound microscope, magnification of objective and eye-piece; to evaluate the accuracy of the measurement.

4. Measuring microobjects by light microscope. Through the use of eye-piece micrometer and eye-piece grid to measure linear size and area of microobjects; to determine thickness of transparent bodies.

5. Determination of average diameter, average area and diameter distribution of erythrocytes - application of statistical concepts. To explain the terms general and statistical totality, random and representative sample; to explain purpose of statistical characteristics average value, standard deviation of an individual measurement, standard deviation of the mean result, confidence probability or confidence level; to determine average diameter, average area and diameter distribution of erythrocytes.

6. Evaluation of liquids dynamic viscosity. To explain difference between laminar and turbulent flow; to explain the viscosity as an internal friction coefficient of a real fluid; to explain purpose of basic parts of the viscometer of Ostvald-Pinkevich; to measure dynamic viscosity of liquid using the capillary method of Poiseuille.

7. Evaluation of liquids surface tension. To explain the terms molecular pressure, cohesion pressure, surface tension; to determine surface tension using method of blowing away air bubbles.

8. Pressure. Air pressure. Blood pressure. Air humidity. To explain the terms pressure, air pressure, blood pressure, and humidity; to explain the Korotkov's method for indirect measurement of blood pressure; to determine humidity using the psychrometer of August.

9. Determination of lens power of spherical lens. To determine the principal focus, focal length, and lens power of a convex lens; to find the image distance, principal focus, focal length, and lens power of a concave lens.

10. Measurement of concentration of biological liquids and pharmaceutical preparations by refractometer. To explain the relationship between the optical refraction and the wave character of light; to explain the dependence of refraction on the light speed; to explain the purpose of basic parts of the refractometer; to determine actual concentration of biological liquids and preparations by index of refraction using refractometer.

11. Measurement of concentration of optically active liquids by polarimeter. To explain difference among linearly, circularly and elliptically polarized light; to explain the polarization of light by double refraction; to explain purpose of basic parts of the polarimeter; to measure actual rotation angle of sugar solutions using polarimeter**.**

12. Electrocardiography (ECG). To explain the origin of electric field and potential distribution around the heart; to explain the connection of different type leads used in electrocardiography; to measure the wave amplitudes and duration of time intervals on the electrocardiogram recorded.

13. Measurements with electric instruments. To explain the difference between a voltmeter and an ammeter; to measure voltage and current in a circuit; to calculate the resistance and power of a circuit element.

14. Graduation of semiconductor thermometer. To explain the difference between conductors, insulators and semiconductors; to explain the difference between the common measurement of resistance and bridge-measurements, to explain the advantages of semiconducting thermometer, to graduate semiconducting thermometer.

15. Graduation of thermoelement. To describe and explain the different thermoelectric effects; to explain what determines the efficiency of a thermoelectric converter; to can graduate a thermoelement.

16. V-A characteristic of crystal diode To explain difference between conductors, insulators, and semiconductors; to explain the terms P-N junction, crystal diode, V-A characteristic; to make measurements and plot a graph of V-A characteristic of a crystal diode.

17. V-A characteristics of Biologically Active Point (BAP). To find a BAP of lung meridian on the base of its low electric resistance; to plot the current-voltage characteristic of BAP at constant pressure of active electrode on the skin

18. Determination of an actual auditory threshold of hearing. To explain relation and difference between objective and subjective sound characteristics; to explain the use of decibel scale to compare sound intensities; to plot actual auditory threshold curve – audiogram.

19. Light measurements: comparison of the intensity of two light sources and determination of the integral sensitivity of photocell. To define luminous and illuminated object; to define the terms of photometry: luminous intensity, luminous flux, illuminance; to compare the luminous intensities of two light sources; to determine the integral sensitivity of a photopile.

20. Measurements with electron oscilloscope. To explain the arrangement of cathode-ray tube; to explain when oscilloscope is preferable to use; to measure the amplitude of voltage and current, period and frequency of sine electric signal.

21. Frequency dependence of human skin impedance. To explain and investigate the dependence of impedance of human skin upon the frequency of electric current; - to define the basic terms of RC circuit; - to model the impedance of the human skin using RC circuit.

22. Revision. To revise the experimental procedures of the topics, to solve some numerical problems

23. Colloquium. It includes experiment performance, theory test and interview.

CONTROL AND EVALUATION OF STUDENTS' KNOWLEDGE

Grades are awarded to students based on the level of performance they have achieved:
- in the lecture tests
- in the lab topics tests
- in the colloquium
- in the semester exam

THE ATTENDANCE TO LECTURES AND PRACTICAL EXERSICES IS MANDATOTORY. THE OMITTED EXPERIMENTAL TOPICS HAVE TO BE REDONE. DURING THE LAB EXERCISES STUDENTS' KNOWLEDGE IS EVALUATED ON THE BASIS OF THE TESTS FOR THE RESPECTIVE TOPIC.

The final (semestral) exam is given during the exam session according to the schedule approved by the Dean.

The final exam consists of a written and oral part and is composed of 3 levels:

1st level: Conversion of units of measure from one form to another;

2nd level: Solving a test on the study material of the type True or False, Fill in the blanks, etc.

3rd level: oral exam according to the synopsis.

In case of poor results on the 1st and/or 2nd levels, the student is not allowed to sit for the oral exam. Only after successfuly passing both the first and second levels, the student is required to answer the questions from the synopsis.

THE POSITION OF THE DISCIPLE IN THE TOTAL EDUCATION IN MEDICINE

The discipline Medical Physics is in the list of compulsory subjects in the Medicine curriculum. It is studied in the first semester of the first year and ends with a semestral exam. The main objective of Medical Physics is to relate some of the concepts in physics to living systems.

The program of study is organized into the following areas: fluid mechanics, heat and wave motion, sound, electricity, optics, and atomic and nuclear physics. Most of the studied material is devoted to the applications of physics to biology and medicine. Whenever possible, the analysis is quantitative, requiring only basic mathematics.

EXPECTED RESULTS

After completing the Medical Physics Program students are expected to understand the basic concepts of physics in all its aspects, from mechanics to modern physics.

They are also expected

- to know physical methods and devices used for prophylaxis, therapy, treatment and control of physiological processes;
- to be acquainted with the effect of physical factors on human organism.

EXAMINATION SYNOPSIS IN MEDICAL PHYSICS
Academic Year 2015/2016

1. Medical physics. The role of the experiment. Measurement. SI system
2. Accuracy and significant digits. Scientific notation. The conversion of units
3. The states of matter. The definition of pressure. Pressure in liquids. Distribution of pressure in a static liquid
4. Transmission of pressure: Pascal's principle. Clinical applications of Pascal's principle
5. Buoyant force and Archimedes' principle
6. Pressure in flowing fluids. Pressure gradient. Laminar and turbulent flow. Poiseuille's law. The resistance to flow
7. Evaluation of liquids dynamic viscosity using the Poiseuille's capillary method
8. Types of pumps. The heart as a force pump
9. The circulatory system. The control of volume flow rate. The applicability of Poiseuille's law
10. Changes in blood speed during circulation. Wall tension and Laplace's law
11. Liquids surface tension. Molecular pressure, cohesion pressure, surface tension coefficient. Evaluation of liquids surface tension by the method of blowing away air bubbles
12. The energy supplied by the heart. The variations of the blood pressure. The measurement of blood pressure
13. The kinetic energy of molecules. Diffusion. Fick’s law. Osmosis. Semipermeable membrane. Osmotic pressure. Hypertonic and hypotonic solutions. Dialysis
14. Transport across living membranes. Passive and active transport. Molecular transfer in the capillary system
15. Cohesion and adhesion. Surface tension. Surface tension and respiration. The role of surfactant. Capillary action. Viscosity. Adsorption and absorption
16. Internal energy. The distinction between internal energy and temperature. Temperature scales
17. Heat and the first law of thermodynamics. Internal energy. Thermal expansion
18. Methods for temperature measurement. Liquid Expansion Thermometers. Bimetallic Strip Thermometers. Constant Volume Gas Thermometer.
19. Internal energy and specific heat. The calorie as a unit of heat or internal energy. Heat of combustion: the dietary calorie. The mechanical equivalent of heat
20. Changes of phase. Applications of phase changes. Application of the melting transition. Refrigeration cycle.
21. Evaporation and vapor pressure. Saturation vapor pressure and saturation vapor density. Boiling point. Relative humidity
22. Heat transfer. Conduction. Fourier's law. Convection. Radiation. Physiological applications of heat transfer
23. The electrical nature of matter. The behavior of electric charges. Coulomb's law
24. The flow of electric charge. Conductors. Insulators and semiconductors. The electroscope. Electric current
25. Electric fields and voltages. The electric field strength. Point charge. Capacitor. Capacitance
26. Basic terms of RC circuit. Modelling the impedance of the human skin using RC circuits. The relationship between the human skin impedance and the frequency of electric current

27. Cathode ray tube. Oscilloscope. Measuring the amplitude of voltages and currents, and the period and frequency of sine electric signals by an oscilloscope
28. Magnets and magnetic fields. Diamagnetics, paramagnetics and ferromagnetics. Electromagnets
29. The interaction between electricity and magnetism. The magnetic force on a moving charge. The motor principle. Magnetic flux. Faraday's law
30. Sensing elements for physiological measurements. Thermocouples. The electrical resistance thermometer. The thermistor.
31. Graduating thermoelectric and semiconducting thermometer.
32. Pressure transducers. The oximeter. Electrodes for PH, Pco2 and Po2. Amplifiers. Triodes and transistors.
33. Evaluation of V-A characteristic of crystal diode
34. Display devices. The oscilloscope. Meters and chart recorders. Digital displays. The defibrillator. Electrocautery and electrosurgery
35. Measurements with electric instruments. Calculation of the resistance and power of a circuit element
36. The living cell as an electric source. The resting potential. The action potential. Sequence of membrane events during an action potential. Depolarization - repolarization
37. The electrocardiogram. How to read an electrocardiogram. The electrical conduction process controlling the heart's pumping cycle. The triangle of Einthoven. The electroencephalogram. Other bioelectric measurements. The electronic pacemaker
38. Elasticity. Hooke's law. Periodic motion and resonance. Frequency and amplitude of periodic motion.
39. Traveling waves. Transverse waves. Longitudinal waves. Speed of propagation. Wavelength. Frequency. Wave properties of sound and light
40. Energy in waves. The intensity of the radiation. Interference and standing waves. Constructive and destructive interference. Standing wave
41. The Doppler effect. Ultrasonic sound. Doppler ultrasound techniques.
42. The mechanism of the ear. The range and sensitivity of human hearing. The decibel scale
43. The distinction between loudness and intensity. Equal loudness curves. Hearing tests. Audiometry
44. Objective and subjective sound characteristics. Determination of threshold of hearing by plotting an auditory threshold curve – audiogram
45. Refraction and lenses. The index of refraction. Lens power. Ray diagrams. Lens equation. The magnification of a lens.
46. Image formation by the eye. Common vision defects
47. Simple optical instruments. The simple magnifier. The compound microscope. The ophthalmoscope. Fiber optics.
48. Measuring micro-objects by compound microscope. Mean diameter, mean area and diameter distribution of erythrocytes (application of statistical concepts)
49. Color vision
50. The electromagnetic spectrum. Types of electromagnetic waves. The quantum theory of light.
51. Matter waves: the electron microscope. Comparison of electron and optical microscopes. Quantum theory of the atom. Pauli exclusion principle
52. The interaction of electromagnetic waves with matter

53. Clinical applications of electromagnetic waves. Radio frequency and microwave radiation
54. Infrared radiation. Ultraviolet radiation.
55. X-ray radiation. Medical imaging with CT and NMR scans
56. The laser and its applications. Metastable states. Population inversion. Mode of laser action
57. Holography: three-dimensional images
58. A scale model of the atom. The nature of the nucleus. The three basic types of radioactivity – alpha, beta and gamma.
59. Radioactive decay and half-life. Medical radioisotopes. The detection of radiation
60. Effects of ionizing radiation on biologic material. Measurement of radiation exposure. How to minimize your exposure. Radiation therapy.
61. Diagnostic use of radioisotopes. Positron emission tomography. Nuclear energy

REFERENCES

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- Davidovits P. Physics in Biology and Medicine. 3rd Edition, © 2008, Elsevier Inc.
- Halliday, D and Resnick R. Fundamentals of physics. Extended 9th Edition, Copyright © 2011, 2008, 2005, 2003 John Wiley & Sons, Inc
- Hobbie RK, Roth BJ. Intermediate Physics for Medicine and Biology. 4th Edition © 2007 Springer Science+Business Media, LLC

AUTHOR OF THE PROGRAM OF STUDY:

Prof. Margarita Alexandrova, DSc, Head of the Division of Physics and Biophysics, Medical University - Pleven