



**Course: Medical Physics and Biophysics**

**Course Coordinator: Gordana Žauhar, PhD, Associate Professor**

**Department: Department of Medical Physics and Biophysics**

**Study program: Integrated Undergraduate and Graduate University Study of Medicine in English**

**Study year: first**

**Academic year: 2021/22**

## SYLLABUS

**Course description (a brief description of the course, general instructions, where and in what form the lessons are organized, necessary equipment, instructions for attendance and preparation for classes, student obligations, etc.):**

Medical Physics and Biophysics is an introductory course, which gives students an insight into the physical principles required for a better understanding of processes in other fields, such as anatomy, biochemistry, physiology, histology, pathology, etc. The purpose of this course is to motivate students to use the analytical and quantitative approach in the research of human body functions.

### COURSE STRUCTURE

Seminars: 20 hours

Practicals: 25 hours

Total hours: 75

During practicals, students will develop abilities and skills in using various measuring devices, which are a part of different medical devices. Upon completing this course, students will be able to collect data, critically evaluate and interpret the results, as well as correctly use the International System of Units and Measurements in medicine.

### Assigned reading:

I.P. Herman. Physics of the Human Body, Springer, Berlin, 2016.

### Optional/additional reading:

R. K. Hobbie, B.J. Roth. Intermediate Physics for Medicine and Biology, Springer, New York, 2015.

### COURSE TEACHING PLAN:

**The list of lectures (with topics and descriptions):**

**L1 Introduction. SI Units.**

**L2 Optics in Medicine. Laws of Refraction and Reflection: Image Formation by Plane and Spherical Surfaces of Refraction.**

**L3 The Human Eye – the Optical Model.**

**L4 Errors of optical systems**

**L5 Image Formation by Lens and Microscope: Resolution of the Microscope and the Eye.**

**L6 Types of Optical Microscopes. Electron microscopes.**

**L7 Fundamental Forces. Statics of the Body. Review of Forces, Torques and Equilibrium.**

**L8 Mechanics of the Human Body. Implementation of Newton's Laws: Levers in the Body, Passive Walking and High Jump.**

**L9 Mechanical Properties of Tissues. Elasticity and Strength of Materials. Viscoelastic Properties of Body Tissues – Mechanical Models.**

**L10 Fluids. Hydrostatics. Surface Tension and Its Implications. Law of Laplace.**

**L11 Hydrodynamics. Bernoulli's Equation, Viscosity and Poiseuille's Law. Turbulent Flow.**

**L12 Rheological Properties of Blood. Physics of the Circulatory System. Consequences of Clogged Arteries.**

**L13 Ideal and Real Gases. Gas Laws. Physics of Breathing.**

**L14 Basic Principles of Thermodynamics: I and II Law.**

**L15 Thermodynamics of a Biological system. Transfer of Heat.**

**L16 Transfer of Particles and Ions through Membranes. Action Potential.**

**L17 Physical Basis of Electro- and Magneto- Diagnostics (EKG, EEG, EMG).**

**L18 Dielectric Properties of Tissues. Tissues in Electric Field. Therapeutic Applications of Electric Fields.**

**L19 Matter in the External Magnetic Field: A Biological System in the Electric Circuit, Magneto therapy**

**L20 Oscillations and Waves**

**L21 Sound Waves: The Physics of Hearing. Intensity of Sound Waves.**

**L22 Connection between Physical and Physiological Parameters of Sound.**

**L23 Structure of Atom and Molecule: Molecular Bonds and Energy States.**

**L24 Electromagnetic Waves.**

**L25 Medical Use of X Rays.**

**L26 Structure of the Atomic Nucleus. Nuclear Decay. Decay Rate and Half-life.**

**L27 Radioactivity. Alfa, Beta and Gamma Decay.**

**L28 Interaction of Photons with Matter. Detection and Dosimetry of Ionizing Radiation.**

**L29 Application of Ultrasound in Medicine.**

**L30 Final Lecture and Preparation for Final Exam**

The list of seminars with descriptions:

**S1 Calculating Measurement Errors and Estimating Measurement Accuracy**

**S2 Optics**

**S3 Vectors and Operations with Vectors. Graphical Representation of Measurement Results and interpretation of Graphs. Differential Calculus.**

**S4 Levers in the Human Body**

**S5 Hydromechanics**

**S6 Physics of Breathing**

**S7 Diffusion and Osmosis. Transport of Energy and Matter through Cell Membranes.**

**S8 Sound. Hearing and the Ear.**

**S9 Medical Use of X-Rays**

**S10 Application of Radioactive Isotopes in Nuclear Medicine**

**The list of practicals with descriptions:**

**Location: Department of Physics, Radmile Matejčić 2 Street, 1st floor, MS TEAMS**

**P0 Introduction to Practicals. General Laboratory Safety Procedures and Rules.**

**P1 Mechanical Waves**

**P2 Audiometry**

**P3 Surface Tension and Viscosity**

**P4 Calorimetry**

**P5 Thermal Environmental Conditions**

**P6 Index of Refraction. Spectroscopy**

**P7 Spherical Mirrors and Lenses**

**P8 Electric Circuits**

**P9 Measurement of Resistance. The Wheatstone Bridge Method.**

**P10 Ionizing radiation**

**P11 Compensation**

**P12 Compensation**

**Students' obligations:**

The attendance at lectures, seminars and practicals is mandatory. If necessary, a student can be absent from 30% of the classes of the overall course workload, but has to make up for the practicals he/she failed to attend. Students' obligations are course attendance and active participation in all practicals and seminars.

Throughout the course, students have two midterm exams (tests) consisting of 14 questions each. Test 1 covers the topics presented in seminars 1-5. Test 2 covers the topics presented in seminars 6-10.

The completion and proper documentation of each practical as well as the consent of the course instructor are required for course completion.

Evaluation of students' work:

Students can obtain a total of 100 credits (a maximum of 50 credits during the course and a maximum of 50 credits on the final exam). Students are allowed to take the final exam if they acquire a minimum of 25 credits during the trimester.

Students who did not gain 50% on each midterm exam may retake their midterm exams.

On the final exam, which is worth 50 credits, a student must obtain at least 50% on the written part of exam.

**Assessment (exams, description of written / oral / practical exam, the scoring criteria):**

	Assessment	Grade Point Maximum
<b>Midterm Exams</b>	Midterm 1 (14 questions)	14
	Midterm 2 (14 questions)	14
	<b>total</b>	<b>28</b>
<b>Practicals</b>	Accepted practicals and reports 10 x 5 x 0.4 credits	20
	<b>total</b>	<b>48</b>
<b>Active participation</b>	Active participation during seminars	2
<b>TOTAL</b>		<b>50</b>
<b>FINAL EXAM</b>	Written part (25 questions)	25
	Oral part	25
	<b>total</b>	<b>50</b>
<b>TOTAL</b>		<b>100</b>

**Partial exams:**

Two midterm exams are scheduled during the trimester.

1. Midterm exam. 14 questions
2. Midterm exam. 14 questions

**Practicals:**

Throughout 10 practicals a student can obtain a maximum of 20 credits.

Each completed and accepted practical is assessed.

**Active participation during seminars:**

During the trimester student participation and dedication will be monitored. A maximum of 2 points is awarded through active participation.

**Final exam:**

Students have to pass the written exam (in form of a test consisting of 25 questions, each containing 5 statements) before approaching the oral exam. In order to pass the written part of the exam students have to score at least 50% (13/25 correct answers).

**Assessment of the written part of the final exam:**

Number of correct answers	Credits
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21
22	22
23	23
24	24
25	25

**Assessment of the oral part of the final exam:**

<b>Grade on oral exam</b>	<b>Credits</b>
sufficient	10-13
good	14-17
very good	18-21
excellent	22-25

The ECTS grading system is defined by the following criteria:

A (5) – 90 - 100 credits

B (4) – 75 - 89,9 credits

C (3) – 60 - 74,9 credits

D (2) – 50 - 59,9 credits

**Other important information regarding to the course:**

**Retaking the course:**

**A student who acquires less than 25 credits during the course has failed the course, is graded with F, and must retake the course MEDICAL PHYSICS AND BIOPHYSICS.**

**COURSE SCHEDULE (for academic year 2021/2022)**

<b>Date</b>	<b>Lectures (time and place)</b>	<b>Seminars (time and place)</b>	<b>Practicals (time and place)</b>	<b>Instructor</b>
02/3/2022 Wednesday	L1-2 (12:15-13:45) O-029 KAMPUS/ online MS Teams			Gordana Žauhar, PhD, Associate Professor
09/3/2022 Wednesday	L3-4 (12:15-13:45) O-029 KAMPUS/ online MS Teams			Gordana Žauhar, PhD, Associate Professor
11/3/2022 Friday		S1 gA (09.00-11.00) LH9  S1 gB (11.00-13.00) LH9		Diana Mance, PhD, Assistant Professor  Diana Mance, PhD, Assistant Professor
16/3/2022 Wednesday			P0 gA (9.00-10.00) O-162 KAMPUS  P0 gB (10.00-11.00) O-162 KAMPUS  P0 gC (11.00-12.00) O-162 KAMPUS	Ana Božanić, Assistant  Ana Božanić, Assistant  Diana Mance, PhD, Assistant Professor
	L5-6 (12:15-13.45) O-029 KAMPUS/ online			Gordana Žauhar, PhD, Associate Professor
18/3/2022 Friday		S2 gA (09.00-11.00) LH9  S2 gB (11.00-13.00) LH9		Diana Mance, PhD, Assistant Professor  Diana Mance, PhD, Assistant Professor
23/3/2022 Wednesday			P1 gA (8.00-10.00) O-162 KAMPUS  P1 gB (10.00-12.00) O-162 KAMPUS  P1 gC (14.00-16.00) O-162 KAMPUS	Ana Božanić, Assistant  Ana Božanić, Assistant  Marta Žuvić, PhD, Full Professor  Diana Mance, PhD, Assistant Professor
	L7-8 (12:15-13.45) O-029 KAMPUS/ online			

25/3/2022 Friday		S3 gA (09.00-11.00) LH9		Diana Mance, PhD, Assistant Professor
		S3 gB (11.00-13.00) LH9		Diana Mance, PhD, Assistant Professor
30/3/2022 Wednesday	L9-10 (12:15-13:45) O-029 KAMPUS/ online MS Teams		P2 gA (8.00-10.00) 0-162 KAMPUS	Ana Božanić, Assistant
			P2 gB (10.00-12.00) 0-162 KAMPUS	Ana Božanić, Assistant
			P2 gC (14.00-16.00) 0-162 KAMPUS	Marta Žuvić, PhD, Full Professor
				Diana Mance, PhD, Assistant Professor
01/4/2022 Friday		S4 gA (09.00-11.00) LH9		Diana Mance, PhD, Assistant Professor
		S4 gB (11.00-13.00) LH9		Diana Mance, PhD, Assistant Professor
06/4/2022 Wednesday	L11-12 (12:15- 13:45) O-029 KAMPUS/ online MS Teams		P3 gA (8.00-10.00) 0-162 KAMPUS	Ana Božanić, Assistant
			P3 gB (10.00-12.00) 0-162 KAMPUS	Ana Božanić, Assistant
			P3 gC (14.00-16.00) 0-162 KAMPUS	Marta Žuvić, PhD, Full Professor
				Diana Mance, PhD, Assistant Professor
08/4/2022 Friday		S5 gA (09.00-11.00) LH9		Gordana Žauhar, PhD, Associate Professor
		S5 gB (11.00-13.00) LH9		Gordana Žauhar, PhD, Associate Professor
13/4/2022 Wednesday	L13-14 (12:15-13:45) O-029 KAMPUS / online MS Teams		P4 gA (8.00-10.00) 0-162 KAMPUS	Ana Božanić, Assistant
			P4 gB (10.00-12.00) 0-162 KAMPUS	Ana Božanić, Assistant
			P4 gC	Marta Žuvić, PhD, Full Professor
				Diana Mance, PhD, Assistant Professor

			(14.00-16.00) 0-162 KAMPUS	
15/4/2022 Friday		1 <sup>st</sup> MIDTERM EXAM (9:00-11:00)		Gordana Žauhar, PhD, Associate Professor Diana Mance, PhD, Assistant Professor Ana Božanić, Assistant
20/4/2022 Wednesday	L15-16 (12:15-13:45) O-029 KAMPUS / online MS Teams		P5 gA (8.00-10.00) 0-162 KAMPUS  P5 gB (10.00-12.00) 0-162 KAMPUS  P5 gC (14.00-16.00) 0-162 KAMPUS	Ana Božanić, Assistant  Ana Božanić, Assistant  Marta Žuvić, PhD, Full Professor  Diana Mance, PhD, Assistant Professor
27/4/2022 Wednesday	L17-18 (12:15-13:45) O-029 KAMPUS / online MS Teams		P6 gA (8.00-10.00) 0-162 KAMPUS  P6 gB (10.00-12.00) 0-162 KAMPUS  P6 gC (14.00-16.00) 0-162 KAMPUS	Ana Božanić, Assistant  Ana Božanić, Assistant  Marta Žuvić, PhD, Full Professor  Diana Mance, PhD, Assistant Professor
29/4/2022 Friday		S6 gA (09.00-11.00) LH9  S6 gB (11.00-13.00) LH9		Gordana Žauhar, PhD, Associate Professor  Gordana Žauhar, PhD, Associate Professor
04/5/2022 Wednesday	L19 (12:15-13:00) L20 (13:15-14:00) O-029 KAMPUS / online MS Teams		P7 gA (8:00-10:00) 0-162 KAMPUS  P7 gB (10:00-13:00) 0-162 KAMPUS  P7 gC (14:15-16:15) 0-162 KAMPUS	Ana Božanić, Assistant  Ana Božanić, Assistant  Marta Žuvić, PhD, Full Professor Gordana Žauhar, PhD, Associate Professor  Diana Mance, PhD, Assistant Professor
06/5/2022 Friday		S7 gA (09:00-11:00) LH9  S7 gB		Gordana Žauhar, PhD, Associate Professor  Gordana Žauhar, PhD, Associate Professor



		(11:00-13:00) LH9		
11/5/2022 Wednesday	L21-22 (12:15-13:45) O-029 KAMPUS / online MS Teams		P8 gA (8.00-10.00) 0-162 KAMPUS  P8 gB (10.00-12.00) 0-162 KAMPUS  P8 gC (14.00-16.00) 0-162 KAMPUS	Ana Božanić, Assistant  Ana Božanić, Assistant  Gordana Žauhar, PhD, Associate Professor  Diana Mance, PhD, Assistant Professor
13/5/2022 Friday		S8 gA (09:00-11:00) LH9  S8 gB (11:00-13:00) LH9		Gordana Žauhar, PhD, Associate Professor  Gordana Žauhar, PhD, Associate Professor
18/5/2022 Wednesday	L23-24 (12:15-13:45) O-029 KAMPUS / online MS Teams		P9 gA (8.00-10.00) 0-162 KAMPUS  P9 gB (10.00-12.00) 0-162 KAMPUS  P9 gC (14.00-16.00) 0-162 KAMPUS	Ana Božanić, Assistant  Ana Božanić, Assistant  Slaven Jurković, PhD, Associate Professor  Diana Mance, PhD, Assistant Professor
20/5/2022 Friday		S9 gA (09.00-11.00) LH9  S9 gB (11.00-13.00) LH9		Slaven Jurković, PhD, Associate Professor  Slaven Jurković, PhD, Associate Professor
25/5/2022 Wednesday	L25-26 (12:15-13:45) O-029 KAMPUS /online MS Teams		P10 gA (8.00-10.00) 0-162 KAMPUS  P10 gB (10.00-12.00) 0-162 KAMPUS	Ana Božanić, Assistant  Ana Božanić, Assistant  Slaven Jurković, PhD, Associate Professor

			P10 gC (14.00-16.00) 0-162 KAMPUS	Diana Mance, PhD, Assistant Professor
27/5/2022 Friday		S10 gA (09.00-11.00) LH9		Slaven Jurković, PhD, Associate Professor
		S10 gB (11.00-13.00) LH9		Slaven Jurković, PhD, Associate Professor
01/6/2022 Wednesday			P11 gA (8.00-10.00) 0-162 KAMPUS	Ana Božanić, Assistant
			P11 gB (10.00-12.00) 0-162 KAMPUS	Ana Božanić, Assistant
	L27-28 (12:15-13.45) O-029 KAMPUS / online MS Teams		P11 gC (14.00-16.00) 0-162 KAMPUS	Slaven Jurković, PhD, Associate Professor  Diana Mance, PhD, Assistant Professor
03/6/2022 Friday		2 <sup>nd</sup> MIDTERM EXAM (9 – 11:00)		Gordana Žauhar, PhD, Associate Professor Diana Mance, PhD, Assistant Professor Ana Božanić, Assistant
08/6/2022 Wednesday			P12 gA (8.00-10.00) 0-162 KAMPUS	Ana Božanić, Assistant
			P12 gB (10.00-12.00) 0-162 KAMPUS	Ana Božanić, Assistant
	L29-30 (12:15-13:45) O-029 KAMPUS / online MS Teams		P12 gC (14.00-16.00) 0-162 KAMPUS	Gordana Žauhar, PhD, Associate Professor  Diana Mance, PhD, Assistant Professor

List of lectures and seminars:

	LECTURES (Topics)	Teaching hours	Location/Lecture room
L1	Introduction. SI Units.	1	0-029 KAMPUS
L2	Optics in Medicine. Laws of Refraction and Reflection: Image Formation by Plane and Spherical Surfaces of Refraction.	1	0-029 KAMPUS
L3	The Human Eye – the Optical Model.	1	0-029 KAMPUS
L4	Errors of optical systems	1	0-029 KAMPUS
L5	Image Formation by Lens and Microscope	1	0-029 KAMPUS
L6	Types of Optical Microscopes. Electron microscopes	1	0-029 KAMPUS
L7	Fundamental Forces. Statics of the Body. Review of Forces, Torques and Equilibrium.	1	0-029 KAMPUS
L8	Mechanics of the Human Body. Implementation of Newton's Laws: Levers in the Body, Passive Walking and High Jump.	1	0-029 KAMPUS
L9	Mechanical Properties of Tissues. Elasticity and Strength of Materials. Viscoelastic Properties of Body Tissues – Mechanical Models.	1	0-029 KAMPUS
L10	Fluids. Hydrostatics. Surface Tension and Its Implications. Law of Laplace.	1	0-029 KAMPUS
L11	Hydrodynamics. Bernoulli's Equation, Viscosity and Poiseuille's Law. Turbulent Flow.	1	0-029 KAMPUS
L12	Rheological Properties of Blood. Physics of the Circulatory System. Consequences of Clogged Arteries.	1	0-029 KAMPUS
L13	Ideal and Real Gases. Gas Laws. Physics of Breathing.	1	0-029 KAMPUS
L14	Basic Principles of Thermodynamics: I and II Law.	1	0-029 KAMPUS
L15	Thermodynamics of a Biological system. Transfer of Heat.	1	0-029 KAMPUS
L16	Transfer of Particles and Ions through Membranes. Action Potential.	1	0-029 KAMPUS
L17	Physical Basis of Electro- and Magneto- Diagnostics (EKG, EEG, EMG).	1	0-029 KAMPUS
L18	Dielectric Properties of Tissues. Tissues in Electric Field. Therapeutic Applications of Electric Fields.	1	0-029 KAMPUS
L19	Matter in the External Magnetic Field: A Biological System in the Electric Circuit, Magneto therapy	1	0-029 KAMPUS
L20	Oscillations and Waves	1	0-029 KAMPUS
L21	Sound Waves: The Physics of Hearing. Intensity of Sound Waves.	1	0-029 KAMPUS
L22	Connection between Physical and Physiological Parameters of Sound.	1	0-029 KAMPUS
L23	Structure of Atom and Molecule: Molecular Bonds and Energy States.	1	0-029 KAMPUS
L24	Electromagnetic Waves.	1	0-029 KAMPUS
L25	Medical Use of X Rays.	1	0-029 KAMPUS
L26	Structure of the Atomic Nucleus. Nuclear Decay. Decay Rate and Half-life.	1	0-029 KAMPUS
L27	Radioactivity. Alfa, Beta and Gamma Decay.	1	0-029 KAMPUS
L28	Interaction of Photons with Matter. Detection and Dosimetry of Ionizing Radiation.	1	0-029 KAMPUS
L29	Application of Ultrasound in Medicine.	1	0-029 KAMPUS
L30	Final Lecture and Preparation for Final Exam.	1	0-029 KAMPUS
	<b>TOTAL TEACHING HOURS</b>	<b>30</b>	

	<b>SEMINARS (Topics)</b>	<b>Teaching hours</b>	<b>Location/Lecture room</b>
S1	Calculating Measurement Errors and Estimating Measurement Accuracy	2	LH9
S2	Optics	2	LH9
S3	Vectors and Operations with Vectors. Graphical Representation of Measurement Results and Interpretation of Graphs. Differential Calculus.	2	LH9
S4	Levers in the Human Body	2	LH9
S5	Hydromechanics	2	LH9
S6	Physics of Breathing	2	LH9
S7	Diffusion and Osmosis. Transport of Energy and Matter through Cell Membranes.	2	LH9
S8	Sound. Hearing and the Ear.	2	LH9
S9	Medical Use of X-Rays	2	LH9
S10	Application of Radioactive Isotopes in Nuclear Medicine	2	LH9
	<b>TOTAL TEACHING HOURS</b>	<b>20</b>	

	<b>FINAL EXAM DATES</b>
1.	13/06/2022
2.	27/06/2022
3.	11/07/2022
4.	02/09/2022
5.	16/09/2022