Sveučilište u Rijeci • Fakultet dentalne medicine
University of Rijeka • Faculty of Dental Medicine

**Course: Biophysics**
**Course Coordinator: Gordana Žauhar, PhD, Associate Professor**
**Department: Department of Medical Physics and Biophysics**
**Study program:** Integrated Undergraduate and Graduate University Study of Dental Medicine
**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.):**

Biophysics is an introductory course that 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
Formal lectures: 25 hours
Seminars: 20 hours
Practicals: 30 hours
Total hours: 75
ECTS: 4
During practical 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, 2010.

Laboratory Practicals, Medical Physics and Biophysics, Faculty of Medicine, Rijeka 2018.

**Optional/additional reading:**

R. K. Hobbie, B.J. Roth. Intermediate Physics for Medicine and Biology, Springer, New York, 2007.
Davidovits Paul. Physics in Biology and Medicine, Academic Press, Elsevier, 2008.

**COURSE TEACHING PLAN:**

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

**L1,2 Introduction, Geometric optics. Optical instruments.**
Learning outcomes:
Introduction to biophysics. Explain the difference between geometric and wave optics, their limitations and applicability.

**L3,4 The eye as an optical instrument.**
Learning outcomes:
Define the principle of how the eye, microscope, magnifying glass and binoculars act. To define and explain reflection and its application in dentistry.

**L5.6 Motion, time, velocity, acceleration, uniform motion in one direction and on a circle, uniformly accelerated motion, centrifuge. Energy: kinetic and potential energy. Forces and their action, types of forces. Centrifugal force, friction, weight, conservation laws, moment of force, momentum.**
Learning outcomes:
To define simple movements - force, consequences of the action of force and types of forces.
To analyse the different forms of energy, distinguish between them, and apply this knowledge to different forces.

**L7.8 Equilibrium, law of levers, deformations of solid bodies. Hook's law, plastic and elastic deformations, hardness, strength. Deformations of human tissue.**
Learning outcomes:
To define equilibrium and the law of levers, as well as their application in biomechanics with special emphasis on their application in dentistry. To analyse that the action of a force on an immobile body results in deformations. To describe deformations using Hooke's Law, to determine when it is applicable, to recognize the differences between the various types of deformations, and apply it to human tissue.

**L9.10 Fluids; pressure, buoyancy, aerometers, volume and mass flow, circulation. Bernoulli's equation and applications, blood flow through the bloodstream, viscosity, Stokes' law**
Learning Outcomes:
To explain the basic laws of fluid motion, understand Bernoulli's equation and its application to human blood flow. Viscosity and its effect on blood flow will be described.

**L11.12 Heat, temperature, heat transfer, basic metabolism, kinetic theory of gasses. Thermodynamic state of the system. States of matter, phase diagrams, crystallization, alloys.**
Learning outcomes:
To define difference between temperature and heat and the laws of heat transfer, thermodynamics and thermodynamic functions as the basis of physiology. Basic knowledge of states of matter and phase transitions will be defined.

**L13,14 Gas laws, partial pressures, solubility of gasses. Basic laws of thermodynamics, entropy, enthalpy, Gibbs function.**
Learning outcomes:
To identify the dissolution of gasses in liquids, the fundamentals of the physics of respiration. Analyze the human organism as a thermodynamic system.

**L15.16 Oscillations. Periodic motions, resonances, waves. Longitudinal and transverse waves, wave interference, sound. Ultrasound and its application in dentistry.**
Learning outcomes:
To describe differences between types of waves, i.e. interference, will be analyzed. To discuss sound and ultrasound and their application in dentistry. To memorise periodic motion. To interpret waves transfer energy and not mass.

**L17,18,19 Electric charge and field. Magnetic field, current and voltage. Charge transfer in matter and vacuum. Dielectric and magnetic properties of matter, electromagnetism, alternating current and voltage, passage of ions across cell membrane. Biological effects of electric current. Diffusion and osmosis.**
Learning outcomes:
To define the basic concepts of electricity and magnetism and apply the acquired knowledge to the passage of ions through the cell membrane. Define the influence of electric current on the human organism. Analyze the importance of diffusion and osmosis.

**L20,21 Atomic structure of matter. The structure of the atomic nucleus. Radioactivity, decay, isotopes. Electromagnetic radiation.**
Learning outcomes:
To describe the structure of matter, especially the atomic nucleus, and the law of radioactive decay and types of decay, production of electromagnetic radiation.

**L22,23 Ionizing radiation. Interaction of radiation and matter.**

Learning outcomes:
Describe how an X-ray machine works, how X-rays interact with matter, and learn how an X-ray image is produced.

**L24,25 Dosimetry and Radiation Protection**
Learning outcomes:
Dosimetric quantities and basic methods of radiation protection are described.

**The list of seminars with descriptions:**

**S1,2 Introduction. Vectors. Examples of vector quantities in physics. Functions and graphs of functions**
Learning outcomes:
To explain the fundamentals of vector calculus to the division of forces and the calculation of the resultant force.
Distinguish between scalar and vector products.
Recognize and apply the physical quantities of work, power, and energy to different types of motion of the human body.
To define conservation laws to solve problems related to different types of motion of the human body.
**S3,4,5 Basic laws of geometric optics. Construct images on mirrors and lenses**
Learning outcomes:
Apply the laws of geometrical optics to solve numerical problems
Analyze image properties of spherical mirrors and lenses for various object distances. Acquire the ability to construct images for spherical mirrors and lenses that allow one to predict where the image will be formed

**S6,7,8 Moment of force. Levers. Solve numerical problems applied in dentistry**
Learning outcomes:
Distinguish between different types of levers and apply them to the human body
Apply the equilibrium conditions to the lever in numerical examples
Apply equilibrium conditions on a lever to numerical examples in dentistry

**S9,10 Hydromechanics. Solve numerical problems**
Learning outcomes:
To use basic physical laws of hydrostatics and hydrodynamics to numerical examples related to human blood flow. To analyse hydraulic resistance in the bloodstream.

**S11,12 Physics of Respiration. Solve numerical problems**
Learning outcomes: Apply basic gas laws in solving numerical examples related to the physics of respiration. Analyze breathing problems at elevated external pressure (during diving).
Discuss breathing problems at reduced external pressure (ascent to high altitudes).

**S13,14 Sound and ultrasound**
Learning outcomes: Define the origin and propagation of sound waves
Analyze numerical examples related to the intensity and loudness of sound.
Analyze the decibel scale.

**S15.16 Diffusion and Osmosis. Bioelectric properties of membranes**
Learning outcomes:
to explain the passage of substances across the cell membrane
Distinguish and explain diffusion and osmosis
Analyze why there is a membrane potential
Analyze Fick's law and the Nernst equation using specific examples
Discuss the passage of neutral and electrically charged particles through the cell membrane

**S17,18 Solve numerical problems involving x-rays and their interaction with matter**
Learning outcomes:
Using numerical examples, observe and conclude how changing the anode voltage and cathode heating current affect the properties of the x-ray radiation spectrum.

Analyze numerical examples of the attenuation of X-rays as they pass through matter.

**S19,20 Solve numerical problems in radioactivity and dosimetry**
Learning outcomes:
Use examples to recognize the differences between radioactive decays.
Apply the law of radioactive decay in numerical examples.
Distinguish and know how to calculate the effective, biological, and physical half-life of a radioactive isotope.

**The list of practicals with descriptions:**

**P0 Introduction. Calculation of errors and analysis of measurement results**
Learning outcomes:
To analyse results and simple errors, to calculate units of measurement and use objects in unit conversions.
To conclude graphical representation and discussed of measurement results.

**P1 Mechanical waves**
Learning outcomes:
To illustrate different types of mechanical waves.
To categorize sound waves using a cathode ray oscilloscope.
To analyze the phenomenon of interference with waves, especially the case in which a standing wave is produced as a result of interference
To determine the natural frequency of vibration of a musical fork based on Melde's experiments.
To analyse the wavelength and propagation velocity of sound with a Quincke whistle.

**P2 Surface tension and viscosity**
Learning outcomes:
To analyse surface tension
To relate the surface tension of a liquid using the ring tear method
To determine the surface tension of a liquid using the capillary rise method
To evaluate viscosity and coefficient of viscosity of a liquid using an Ostwald viscometer

**P3 Audiometry**
Learning outcomes
Define and explain sound intensity, intensity level, and loudness.
Differentiate between tone, musical sound, and noise.
Describe the connection between acoustic parameters and physiological sensations.
Learn about the physical principles behind audiometry.

**P4 Calorimetry**
Learning outcomes:
Distinguish between heat capacity and specific heat capacity of a substance
To relate and able to apply Richman's rule for determining the specific heat capacity of a substance
Evaluate the specific heat of fusion of a substance and of the fusion of ice

**P5 Evaluation of the thermal conditions in the environment**
Learning outcomes:
To grade the basic ways of heat transfer between the organism and the environment
To analyse humidity and know how to determine it
Evaluate the velocity of air flow in a room
Deduce the mean radiation temperature in the room

**P6 Electrical circuits**
Learning outcomes:
To conclude the ability to use simple measuring instruments
Correlate different electric circuits and try to explain changes in the brightness of light bulbs in the circuit or measured values of voltage and current using basic laws, such as: Ohm's law, Kirchohoff's rules

**P7 Refraction of light**
*Learning outcomes*
Understand the law of refraction of light.
Apply the law of refraction to calculate the refractive index of a glass plate and prism.
Know the principle of operation of the spectroscope.
Distinguish between a line spectrum and a continuous spectrum.

**P8 Spherical mirrors and lenses**
*Learning outcomes*
Analyse the characteristics of the image formed by spherical mirrors and lenses for various object distances.
Apply the conjugation equation to calculate the focal length of spherical mirrors and lenses.
Construct images for spherical mirrors and lenses.

**P9 Measurement of electrical resistance using a Wheatstone bridge**
Learning outcomes:
Define resistance and conductivity
To analyse the principle of operation of the Wheatstone bridge and be able to determine resistance using it
To analyse the electrical conductivity of the electrolyte and use the experiment, to determine what it depends on

**Students' obligations:**

The attendance at lectures, seminars and practical 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 practical he/she failed to attend. Students' obligations are course attendance and active participation in all practical and seminars.
Throughout the course, students have two midterm exams (tests) consisting of 13 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.
Student grading is conducted according to the current Ordinance on Studies of the University of Rijeka (approved by the Senate).

**Assessment (exams, description of written / oral / practical exam, the scoring criteria):**
Student grading is conducted according to the current Ordinance on Studies of the University of Rijeka.
Students can obtain 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** | **Grade Point Maximum** |
|---|---|---|
| **Midterm Exams** | Midterm 1 (13 questions) | 13 |
| | Midterm 2 (13 questions) | 13 |
| | **total** | **26** |
| **Practicals** | Accepted practicals and reports<br>12 x 5 x 0.35 credits | 21 |
| | **total** | **47** |
| **Active participation** | Active participation during seminars | **3** |
| **TOTAL** | | **50** |
| **FINAL EXAM** | Written part (25 questions) | 25 |
| | Oral part | 25 |
| | **total** | **50** |

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|---|---|---|
| **TOTAL** | | **100** |

**Partial exams:**
Two midterm exams are scheduled during the trimester.
1. Midterm exam. 13 questions
2. Midterm exam. 13 questions

**Practicals:**
Throughout 12 practicals a student can obtain a maximum of 21 credits.
Each completed and accepted practical is assessed.

**Active participation during seminars:**
During the trimester, student's participation and dedication will be monitored. A maximum of 3 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:**

| Grade on oral exam | Credits |
|---|---|
| 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
F (1) - > 49.9 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 and is graded with F and must retake the course BIOPHYSICS.

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

| Date | Lectures (time and place) | Seminars (time and place) | Practicals (time and place) | Instructor |
|---|---|---|---|---|
| 20/12/2021 Monday | L1-2 (08:15-10:00) O-152 / Online MS Teams | S1 (10:00-12:00) O-152 | P0 (14:00-16:00) O-162 | Gordana Žauhar, PhD, Associate Professor<br>Diana Mance, PhD Assistant Professor<br>Ivan Pribanić, Assistant |
| 21/12/2021 Tuesday | L3-4 (10:00-12:00) O-152 / Online MS Teams | S2 (12:00-14:00) O-152 | P1 (15:00-17:00) O-162 | Gordana Žauhar, PhD, Associate Professor<br>Diana Mance, PhD, Assistant Professor<br>Ivan Pribanić, Assistant |
| 22/12/2021 Wednesday | | S3 (12:00-14:00) O-152 | P2 (14:00-16:00) O-162 | Diana Mance, PhD, Assistant Professor<br>Ivan Pribanić, Assistant |
| 23/12/2021 Thursday | L5-6 (09:15-11:00) O-152 / Online MS Teams | S4 (11:00-13:00) O-152 | | Gordana Žauhar, PhD, Associate Professor<br>Diana Mance, PhD, Assistant Professor |
| 10/1/2022 Monday | L7-8 (12:00-14:00) O-152 / Online MS Teams | | P3 (14:00-16:00) O-162 | Diana Mance, PhD, Assistant Professor<br>Ivan Pribanić, Assistant |
| 11/1/2022 Tuesday | L9-10 (10:15-12:00) O-152 / Online MS Teams | S5 (12:00-14:00) O-152 | P4 (15:00-17:00) O-162 | Diana Mance, PhD, Assistant Professor<br>Diana Mance, PhD, Assistant Professor<br>Ivan Pribanić, Assistant |
| 12/1/2022 Wednesday | | | P5 (14:00-16:00) O-162 | Ivan Pribanić, Assistant |
| 13/1/2022 Thursday | L11-12 (10:15-12:00) O-152 / Online MS Teams | | | Diana Mance, PhD Assistant Professor |
| 14/1/2022 Friday | | **First midterm exam** (10:00-12:00) O-152 | P6 (12:00-14:00) O-162 | Diana Mance, PhD Assistant Professor<br>Ivan Pribanić, Assistant |

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|---|---|---|---|---|
| 17/1/2022<br>Monday | L13-14 (10:00-12:00)<br>O-152 / Online MS Teams | S6<br>(12.15-14.00)<br>O-152 | P7<br>(08.00-10.00)<br>O-162 | Ivan Pribanić, Assistant<br>Diana Mance, PhD Assistant Professor<br>Gordana Žauhar, PhD, Associate Professor |
| 18/1/2022<br>Tuesday | | | P8<br>(15.00-17.00)<br>O-162 | Ivan Pribanić, Assistant |
| 19/1/2022<br>Wednesday | | | P9<br>(14.00-16.00)<br>O-162 | Ivan Pribanić, Assistant |
| 20/1/2022<br>Thursday | L15-16 (10:15-12:00)<br>O-152 / Online MS Teams | S7<br>(12.00-14.00)<br>O-152 | | Gordana Žauhar, PhD, Associate Professor<br>Gordana Žauhar, PhD, Associate Professor |
| 21/1/2022<br>Friday | L17-18 (08:15-10:00)<br>O-152 / Online MS Teams | S8<br>(12.00-14.00)<br>O-152 | P10<br>(10.00-12.00)<br>O-162 | Gordana Žauhar, PhD, Associate Professor<br>Ivan Pribanić, Assistant<br>Gordana Žauhar, PhD, Associate Professor |
| 24/1/2022<br>Monday | L19-20 (10:15-12:00)<br>O-152 / Online MS Teams | S9<br>(12.00-14.00)<br>O-152 | P11<br>(14.00-16.00)<br>O-162 | Slaven Jurković, PhD, Associate Professor<br>Slaven Jurković, PhD, Associate Professor<br>Ivan Pribanić, Assistant |
| 25/1/2022<br>Tuesday | L21-22 (10:15-12:00)<br>O-152 / Online MS Teams | S10<br>(12.00-14.00)<br>O-152 | P12<br>(14.00-16.00)<br>O-162 | Slaven Jurković, PhD, Associate Professor<br>Slaven Jurković, PhD, Associate Professor<br>Ivan Pribanić, Assistant |
| 26/1/2022<br>Wednesday | L23 (10:15-11:00)<br>O-152 / Online MS Teams | | P13<br>(11.00-13.00)<br>O-162 | Slaven Jurković, PhD, Associate Professor<br>Ivan Pribanić, Assistant |
| 27/1/2022<br>Thursday | L24-25 (12:15-14:00)<br>O-152 / Online MS Teams | **Second midterm exam**<br>(10:00-12:00)<br>O-152 | | Gordana Žauhar, PhD, Associate Professor<br>Gordana Žauhar, PhD, Associate Professor |

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|---|---|---|---|---|
| 28/1/2022<br>Friday | | | P14<br>(12:00-14:00)<br>O-162 | Ivan Pribanić, Assistant |

**List of lectures and seminars:**

| | LECTURES (Topics) | Teaching hours | Location/Lecture room |
|---|---|---|---|
| L1,2 | Introduction. Vectors. Examples of vector quantities in physics. Functions and graphs of functions | 2 | Department of Physics/ O-152 |
| L3,4 | The eye as an optical instrument | 2 | O-152 / Online MS Teams |
| L5,6 | Motion, time, velocity, acceleration, uniform motion in one direction and on a circle, uniformly accelerated motion, centrifuge. Energy: kinetic and potential energy. Forces and their action, types of forces. Centrifugal force, friction, weight, conservation laws, moment of force, momentum. | 2 | O-152 / Online MS Teams |
| L7,8 | Equilibrium, law of levers, deformations of solid bodies. Hook's law, plastic and elastic deformations, hardness, strength. Deformations of human tissue | 2 | O-152 / Online MS Teams |
| L9,10 | Fluids; pressure, buoyancy, aerometers, volume and mass flow, circulation. Bernoulli's equation and applications, blood flow through the bloodstream, viscosity, Stokes' law | 2 | O-152 / Online MS Teams |
| L11,12 | Heat, temperature, heat transfer, basic metabolism, kinetic theory of gasses. Thermodynamic state of the system. States of matter, phase diagrams, crystallization, alloys. | 2 | O-152 / Online MS Teams |
| L13,¸14 | Gas laws, partial pressures, solubility of gasses. Basic laws of thermodynamics, entropy, enthalpy, Gibbs function. | 2 | O-152 / Online MS Teams |
| L15,16 | Oscillations. Periodic motions, resonances, waves. Longitudinal and transverse waves, wave interference, sound. Ultrasound and its application in dentistry. | 2 | O-152 / Online MS Teams |
| L17-19 | Electric charge and field. Magnetic field, current and voltage. Charge transfer in matter and vacuum. Dielectric and magnetic properties of matter, electromagnetism, alternating current and voltage, passage of ions across cell membrane. Biological effects of electric current. Diffusion and osmosis. | 3 | O-152 / Online MS Teams |
| L20,21 | Atomic structure of matter. The structure of the atomic nucleus. Radioactivity, decay, isotopes. Electromagnetic radiation. | 2 | O-152 / Online MS Teams |
| L22,23 | Ionizing radiation. Interaction of radiation and matter. | 2 | O-152 / Online MS Teams |
| L24,25 | Dosimetry and Radiation Protection | 2 | O-152 / Online MS Teams |
| L23 | Dielectric Properties of Tissues. Tissues in Electric Field. Therapeutic Applications of Electric Fields. | 1 | O-152 / Online MS Teams |
| L24 | Matter in the External Magnetic Field: A Biological System in the Electric Circuit, Magneto therapy | 1 | O-152 / Online MS Teams |
| L25 | Final Lecture and Preparation for Final Exam. | 1 | O-152 / Online MS Teams |
| | TOTAL TEACHING HOURS | **25** | |

| | SEMINARS (Topics) | Teaching hours | Location/Lecture room |
|---|---|---|---|
| S1,2 | Introduction. Vectors. Examples of vector quantities in physics. Functions and graphs of functions | 2 | Department of Physics/ O-152 |
| S3,4,5 | Basic laws of geometric optics. Construct images on mirrors and lenses | 3 | O-152 / Online MS Teams |
| S6,7,8 | Moment of force. Levers. Solve numerical problems applied in dentistry | 3 | O-152 / Online MS Teams |
| S9,10 | Hydromechanics. Solve numerical problems | 2 | O-152 / Online MS Teams |
| S11,12 | Physics of Respiration. Solve numerical problems | 2 | O-152 / Online MS Teams |
| S13,14 | Sound and ultrasound | 2 | O-152 / Online MS Teams |
| S15,16 | Diffusion and Osmosis. Bioelectric properties of membranes | 2 | O-152 / Online MS Teams |
| S17,18 | Solve numerical problems involving x-rays and their interaction with matter | 2 | O-152 / Online MS Teams |
| S19,20 | Solve numerical problems in radioactivity and dosimetry | 2 | O-152 / Online MS Teams |
| | TOTAL TEACHING HOURS | **20** | |

| | PRACTICALS (Topics) | Teaching hours | Location/Lecture room |
|---|---|---|---|
| P0 | Introduction. Calculation of errors and analysis of measurement results | 2 | Department of Physics/ O-152 |
| P1 | Mechanical waves | 4 | O-152 / Online MS Teams |
| P2 | Surface tension and viscosity | 2 | O-152 / Online MS Teams |
| P3 | Audiometry | 4 | O-152 / Online MS Teams |
| P4 | Calorimetry | 2 | O-152 / Online MS Teams |
| P5 | Evaluation of the thermal conditions in the environment | 4 | O-152 / Online MS Teams |
| P6 | Electrical circuits | 2 | O-152 / Online MS Teams |
| P7 | Refraction of light | 4 | O-152 / Online MS Teams |
| P8 | Spherical mirrors and lenses | 4 | O-152 / Online MS Teams |
| P9 | Measurement of electrical resistance using a Wheatstone bridge | 2 | O-152 / Online MS Teams |
| | TOTAL TEACHING HOURS | **30** | |

| | FINAL EXAM DATES |
|---|---|
| 1. | 28/01/2022 |
| 2. | 11/02/2022 |
| 3. | 30/06/2022 |