# Biophysics

Code: 102962
ECTS Credits: 7

2024/2025

| Degree | Type | Year |
|---|---|---|
| 2502442 Medicine | FB | 1 |

## Contact

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## Teachers

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## Teaching groups languages

You can view this information at the end of this document.

## Prerequisites

To profit the most of the course, the student should either have, or do the effort to acquire, the theoretical knowledge and the problem-solving competencies corresponding to higher secondary school courses in Physics and Mathematics.

## Objectives and Contextualisation

The Biophysics course is part of the basic training in the first two years of the Medical Degree.

One of its main objectives is to explain the physical bases of the functioning of some of the organs and systems of the human body that have a strong physical component, both in health and under certain pathological conditions.

Another primary objective is to explain the physical bases of diagnostic and intervention techniques that define modern medicine, such as radiographic imaging, ultrasound imaging, electrocardiograms, hemodialysis, and audiogram.

Finally, the course provides physical foundation useful for other basic courses such as Medical Physiology or Anatomy of the Musculoskeletal System, as well as for clinical specialties such as Pathophysiology, Diagnostic and Interventional Radiology, Cardiology, Pulmonology, Otorhinolaryngology and Ophthalmology.

## Competences

- Communicate clearly, orally and in writing, with other professionals and the media.
- Critically assess and use clinical and biomedical information sources to obtain, organise, interpret and present information on science and health.
- Demonstrate a sufficient command of English, both oral and written, for effective scientific and professional communication.
- Demonstrate knowledge of the principles and physical, biochemical and biological processes that help to understand the functioning of the organism and its disorders.
- Demonstrate understanding of the basic sciences and the principles underpinning them.
- Demonstrate understanding of the mechanisms of alterations to the structure and function of the systems of the organism in illness.
- Demonstrate understanding of the structure and function of the body systems of the normal human organism at different stages in life and in both sexes.
- Demonstrate, in professional activity, a perspective that is critical, creative and research-oriented.
- Formulate hypotheses and compile and critically assess information for problem-solving, using the scientific method.
- Use information and communication technologies in professional practice.

## Learning Outcomes

1. Communicate clearly, orally and in writing, with other professionals and the media.
2. Demonstrate a sufficient command of English, both oral and written, for effective scientific and professional communication.
3. Demonstrate, in professional activity, a perspective that is critical, creative and research-oriented.
4. Explain the physical bases of the structure and function of the systems of the human organism.
5. Formulate hypotheses and compile and critically assess information for problem-solving, using the scientific method.
6. Identify alterations to the structure and function of the biomolecules involved in vision.
7. Identify the basic processes of life on various levels of organisation: molecule, tissue, organ and individual.
8. Identify the physical principles that help to understand the functioning of the organism, at both cell and tissue level.
9. Identify the rules that govern energy transfer in the chemical processes of the human organism.
10. Use information and communication technologies in professional practice.
11. Use specific bibliographic sources and databases on biophysics to work independently on acquiring further knowledge.

## Content

Unit 1. INTRODUCTION TO BIOMECHANICS AND ELASTICITY

*Statics:*
Balance of a body. Equilibrium conditions. Mechanical advantage of levers. Joints and degrees of freedom.

*Gravity and balance:*
Effects of gravity on the human body. Centre of gravity and body balance. Gravitational line and base of support.

*Action of forces on solids:*
Elasticity. Hooke's law. Energy of elastic deformation. Inelastic bodies. Residual deformation. Viscoelasticity. Traction, compression, shearing, torsion and bending.

*Physical properties of the bones:*
Bone elasticity and resistance. Architectural arrangement of bones.

Unit 2. BIOPHYSICS OF BLOOD CIRCULATION

*Pressure:*
Hydrostatic pressure as energy per unit of volume. Arterial pressures. Hydrostatic pressure along the systemic vascular circuit and the pulmonary circuit. Ventricular pressures throughout the cardiac cycle. Opening and closing pressures of cardiac valves.

*Viscous resistance and Poiseuille equation:*
Blood viscosity. Shear stress and atherogenesis. Viscous resistance. Poiseuille equation. Systemic vascular resistance. Resistance associations. Laminar and turbulent flows.

*Bernoulli equation:*
Bernoulli's equation and its medical implications.

*Blood vessels:*
Continuity equation. Vascular tension and Laplace's law. Vascular compliance.

*Seminar:*
Collaborative team work to apply the acquired theoretical foundations to understand various medically relevant scenarios. Presentation of the physical bases of the electrocardiogram.

Unit 3. BIOPHYSICS OF RESPIRATION

*Ventilatory mechanics:*
Lung volumes and capacities. Mechanical pressures involved in ventilation. The basic respiratory cycle. Pulmonary compliance.

*Partialpressuresand alveolar exchange:*
Partial pressure. Inspired air conditioning. Alveolar diffusion. Fick's law. Bases of oxygen therapy. P/F ratio. Blood oxygenation in health and limitations in pathological alterations. V/Q ratio.

*Respiratory resistance:*
Airway resistance. Alveolar surface tension and Laplace's law. Role of the pulmonary surfactant.

*Seminar:*
Collaborative team work to apply the acquired theoretical bases to understand different medically relevant scenarios. Presentation of the physical bases of mechanical ventilation and manipulation of a training simulator.

Unit 4. PHYSICAL FOUNDATIONS OF RADIATION AND RADIOACTIVITY - MEDICAL APPLICATIONS

*Nature and properties of electromagnetic waves (OEM):*
Electromagnetic spectrum. Production and general properties of X-rays.

*Fundamentals of radiology:*
Radioactive emission. Activity. Types of particles. Interaction with matter. Ionization. Biological effects. Dose. Survival curves.

*Medical applications:*
Gammagraphy. DXA (Dual energy X-ray Absorptiometry). PET (Proton Emission Tomography).

*Seminars:*
Examples and cases of imaging techniques with a physics basis (X-rays, DEXA, NMR, PET, scintigraphy); effect of radiations on the human body; examples of radiotherapy.

Unit 5. BIOPHYSICS OF VISION

*Geometric optics:*
Bases of optical physics. Converging and diverging lenses. Image formation. Power-focal distance ratio.

*The eye as an optical system:*
Structure of the eye. Optical parameters of the eye. Crystalline lens and accommodation mechanism. Maximum power and minimum power. Near point and remote point. Breadth of accommodation. Presbyopia.

*Ametropias - abnormalities in image formation:*
Most common ametropias: presbyopia, myopia, farsightedness and astigmatism. Correction of the different ametropias. Cataracts.

*Visual photoreceptors and colour vision:*
Visual photoreceptors of the retina. Visual acuity. Molecular mechanisms of vision. Colour vision and anomalies.

*Seminar:*
Practical exercises will be carried out aimed at interpreting the basic information in the optical evaluation of vision, and to calculate the different parameters presented in the theory. For instance, we will understand what a "VL UD-1.5" graduation means, and which would be the furthest distance at which the eye could focus on objects without wearing corrective lenses in this case.

Unit 6. DIFFUSION PHENOMENA - OSMOSIS AND DIALYSIS

*Physical bases of diffusion phenomena:*
Simple diffusion, kinetic-molecular theory. Fick's law. Diffusion coefficient. Diffusion through membranes. Osmosis, characteristics and applications. Dialysis, characteristics and applications.

*Seminar:*
Study of health and disease states that involve diffusion phenomena and osmotic imbalances.

Unit 7. BIOPHYSICS OF VOICE PRODUCTION AND HEARING

*Physical Basis of Hearing and Audiometry:*
Intensity and its perception. The decibel scale. Auditory thresholds. Long-term damage threshold. The audiogram. Acoustic alterations in the most prevalent hearing losses. Equal-loudness contours. Recruitment.

*Physical nature of the voice and physical bases of its production:*
Aerodynamic-myoelastic explanation of phonation. Simple sounds and complex sounds. Harmonics. Frequency spectrum and cochlear stimulus. Resonances in the vocal tract and vocal formants.

*Integration: Audiology and physical basis of auditory analysis of speech sounds:*
Physical bases of the auditory apparatus function. The middleear as an adapter of acoustic impedances.The Eustachian tube as equalizer of acoustic impedance. Inner ear: tonotopic organization of the basilar membrane and analysis of complex sounds.

*Seminar:*
Simulation of hearing in patients with some of the most prevalent. hearing losses; discussion of the consequences. Simulation of hearing through a cochlear implant. Presentation of the physical bases of tympanometry and of cochlear implant.

## Activities and Methodology

| Title | Hours | ECTS | Learning Outcomes |
|---|---|---|---|
| Type: Directed | | | |
| Laboratory practices (PLAB) | 15.5 | 0.62 | 1, 4, 5, 7, 6, 8 |
| Seminars (SEM) | 15.5 | 0.62 | 1, 2, 3, 4, 5, 7, 6, 8, 9, 11, 10 |
| Theory classes (TE) | 31 | 1.24 | 4, 5, 7, 6, 8 |
| Type: Supervised | | | |
| Tutorials | 3.5 | 0.14 | 1, 4, 7, 6, 8, 9 |
| Type: Autonomous | | | |
| Study | 64 | 2.56 | 2, 4, 5, 7, 6, 8, 9, 11, 10 |
| Work to prepare the cases and problems for the seminar sessions; preparation of the laboratory practices | 35 | 1.4 | 4, 5, 8, 11 |

Theory classes (TE): Plenary lectures.

Seminars (SEM): Active, meaningful, collaborative peer-learning, to convert knowledge into competencies. Study and discussion of scenarios, cases and problems of medical interest. Work in collaborative teams of 4-5 students. It is of outmost importance that the student studies the theory of the corresponding unit prior to the session. In some cases, contents not covered in the theory classes will also be addressed and evaluated. There are 10 seminars associated with the different units. Although attendance is not compulsory, many of the competencies evaluated in the exams are acquired through the work that the student performs in the seminars.

Laboratory practices (PLAB): Five sessions where phenomena studied in theory classes and seminars are visualized and manipulated. Depending on the practice, work is carried out either in pairs or in collaborative teams. It is of outmost importance that the student studies the theory of the corresponding unit prior to the session.

- Biomechanics of the Ankle (associated to Unit 1).
- Model of the Systemic Vascular Circulation (associated to Unit 2).
- Physics of Medical Ultrasound (autonomous unit, theoretical basis acquired during the practice).
- Vision Optics (associated to Unit 5).
- Voice and Hearing (associated to Unit 7).

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

## Assessment

## Continous Assessment Activities

| Title | Weighting | Hours | ECTS | Learning Outcomes |
|---|---|---|---|---|
| Partial 1- Objective multiple choice test to evaluate theoretical and practical knowledge, and reasoning and problem solving competencies, Units 1, 2 and 3, lab practices 1 and 2. | 36% | 3 | 0.12 | 4, 7, 6, 8, 11 |
| Partial 2- Objective multiple choice test to evaluate theoretical and practical knowledge, and reasoning and problem solving competencies, Units 4 and 5, laboratory practices 3 and 4. | 40% | 3 | 0.12 | 4, 7, 6, 8, 11 |
| Partial 3- Objective multiple choice test to evaluate theoretical and practical knowledge, and reasoning and problem solving competencies, Units 6 and 7, laboratory practice 5. | 24% | 2 | 0.08 | 4, 7, 6, 11 |
| Written reports - Laboratory practices results. | 10% | 2.5 | 0.1 | 1, 2, 3, 4, 5, 6, 8, 9, 11, 10 |

Continuous Assessment

The subject will be assessed throughout the course with three partial exams (P1, P2, and P3), which are eliminatory. Each of these partial exams will consist of an objective test aimed at demonstrating the integration of theoretical knowledge and the acquisition of practical skills from the corresponding seminars and laboratory practices. The tests will consist of multiple-choice questions with 4 answers, of which 1, 2, or 3 can be correct; incorrect answers will be penalized proportionally.

The grades for the partial exams must be equal to or greater than 4.5 to be averaged.

The final grade for the subject will be obtained using the following formula: (P1 (36%) + P2 (40%) + P3 (24%)) * 0.9 + PLABs reports grade * 0.1.

To pass the subject, the final grade must be equal to or greater than 5.0.

Make-up Exams

In the case of not passing the subject through continuous assessment, there is the option to re-evaluate the exams corresponding to the partials that have obtained a grade lower than 4.5.

It is important to note that, according to the School of Medicine's assessment regulations, to be able to participate in the make-up exam, you must have attended at least two of the three partial exams.

The make-up exams will have the same format and objectives as the partial exams.

You must pass the make-up exams with a score equal to or greater than 4.5.

To pass the subject after the make-up exams, the final average must reach a minimum grade of 5.0 (grade including the exams and practicals according to the same calculation indicated above). Otherwise, the maximum final grade obtained will be 4.8.

Students with partial grades equal to or greater than 4.5, but with an overall average lower than 5.0 (grade including the practicals according to the formula indicated above), can opt for the make-up of the partial or partials they consider, by communicating their choice in advance tothe subject coordinator. In this case, the final grade of the partial(s) will always be the one obtained in the last exam.

Students with an overall grade equal to or higher than 5.0 from continuous evaluation, cannot take referral tests to improve their grade (UAB academic regulations, Article 116, Assessment results, point 5: "Once the course or module is passed, it cannot be re-evaluated. ")

Single evaluation

The single evaluation consists of a single synthesis test that covers all the contents in the course. Objective test with multiple choice items, with 4 answers, of which 1, 2 or 3 can be true; wrong answers subtract proportionally.

The test consists of two blocks:

- Evaluation of the integrated learning of theoretical knowledge plus practical skills acquired in the seminars and in the laboratory practices. 90% of the mark.
- Specific evaluation of the understanding of the concepts visualized in the laboratory practices. 10% of the mark.

The test will coincide with the date and time set in the Medical School's calendar for the test corresponding to the third partial of the continuous assessment.

To pass the course, the final mark must be equal to or higher than 5.0.

In case the test does not reach the 5.0 mark, a retake test, with the same single evaluation format, will be held the same day and time set in the Medical School's calendar for the continuous evaluation.

Not Evaluable student

It will be considered as 'Not Evaluable' the students who do not take both the theoretical and practical assessment tests, exhausting the rights to the subject's enrollment.

Exam marking review

After each test, a period will be announced for the individual review of the marks.

Proof of participation

If needed for empoyment-related reasons, the student may request a document certifying the participation in the various evaluation activities. The request must be sent by mail to the course coordinator.

Misconduct

In the event of student misconduct (e.g. copying in an exam, plagiarism of an evaluated report, faking a compulsory participation), the corresponding mark will be 0. In the event of a second irregularity, the final grade of the subject will be 0 and the Coordination of the Degree in Medicine will be informed.

## Bibliography

GENERAL

Physics of the Human Body. I.P. Herman (2007). Springer.
e-book: https://bibcercador.uab.cat/permalink/34CSUC_UAB/1eqfv2p/alma991010401169706709

Medical Physics. Physical Aspects of Organs and Imaging. H. Zabel (2017). De Gruyter Textbook.
e-book: https://bibcercador.uab.cat/permalink/34CSUC_UAB/1eqfv2p/alma991010485419506709

Handbook of Physics in Medicine and Biology, R. Splinter (2010). Boca Raton, CRC Press/Taylor & Francis Group.
e-book: https://bibcercador.uab.cat/permalink/34CSUC_UAB/1eqfv2p/alma991010483189506709

Tratado de Fisiología Médica. J.E. Hall & M.E. Hall (2021). Elsevier.
e-book: https://bibcercador.uab.cat/permalink/34CSUC_UAB/1eqfv2p/alma991010357582706709

Hyperphysics, introductory resource to Physics:
http://hyperphysics.phy-astr.gsu.edu/hbase/index.html

ADDITIONAL SPECIFIC

Unit 1: Fundamentals of Biomechanics. D. Knudson (2021). Springer Books.
e-book:
https://bibcercador.uab.cat/discovery/fulldisplay/cdi_springer_books_10_1007_978_3_030_51838_7/34CSUC_UA

Unit 2: The Mechanics of the Circulation. C.G. Caro *et al.* (2011). Cambridge University Press.
e-book:
https://bibcercador.uab.cat/permalink/34CSUC_UAB/1c3utr0/cdi_askewsholts_vlebooks_9781139013406

Unit 3: Fisiología respiratoria: lo esencial en la práctica clínica. W. Crisancho (2022). Ed. El Manual Moderno.
e-book: https://bibcercador.uab.cat/permalink/34CSUC_UAB/1eqfv2p/alma991010619939306709

Unit 4: Radiobiology for the Radiologist. E.J. Hall et al. (2018), Ed. Lippincott Williams & Wilkins.
e-book: https://bibcercador.uab.cat/permalink/34CSUC_UAB/1c3utr0/cdi_proquest_ebookcentral_EBC5829217

Unit 5: Physics of the Human Body. I.P. Herman (2007). Springer. Chapter 11.
e-book: https://bibcercador.uab.cat/permalink/34CSUC_UAB/1eqfv2p/alma991010401169706709

Unit 6: Medical Physics. Physical Aspects of Organs and Imaging. H. Zabel (2017). De Gruyter Textbook.
e-book: https://bibcercador.uab.cat/permalink/34CSUC_UAB/1eqfv2p/alma991010485419506709

Unit 7: Tratado de Audiología. Enrique Salesa etal. (2013). Elsevier-Masson.
e-book:
https://bibcercador.uab.cat/permalink/34CSUC_UAB/1c3utr0/cdi_askewsholts_vlebooks_9788445823958

## Software

*Praat* software for voice analysis in auditory laboratory work.

## Language list

| Name | Group | Language | Semester | Turn |
|---|---|---|---|---|
| (PLAB) Practical laboratories | 101 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 102 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 103 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 104 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 105 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 106 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 107 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 108 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 109 | Catalan | annual | morning-mixed |

| | | | | |
|---|---|---|---|---|
| (PLAB) Practical laboratories | 110 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 111 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 112 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 113 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 114 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 115 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 116 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 117 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 118 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 119 | Catalan | annual | morning-mixed |
| (PLAB) Practical laboratories | 120 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 101 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 102 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 103 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 104 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 105 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 106 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 107 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 108 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 109 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 110 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 111 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 112 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 113 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 114 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 115 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 116 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 117 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 118 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 119 | Catalan | annual | morning-mixed |
| (SEM) Seminars | 120 | Catalan | annual | morning-mixed |

| | | | | |
|---|---|---|---|---|
| (TE) Theory | 101 | Catalan | annual | afternoon |
| (TE) Theory | 102 | Catalan | annual | afternoon |
| (TE) Theory | 103 | Catalan | annual | afternoon |
| (TE) Theory | 104 | Catalan | annual | afternoon |