Universitat Autònoma de Barcelona

2023/2024

Biophysics

Code: 102962
ECTS Credits: 7

Degree	Type	Year	Semester
2502442 Medicine	FB	1	A

Contact

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Teaching groups languages

You can check it through this link. To consult the language you will need to enter the CODE of the subject. Please note that this information is provisional until 30 November 2023.

Teachers

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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 first two years of basic training in the Degree in Medicine.

One of its main objectives is to explain the physical bases of the functioning of some of the organs and systems of the human organism with a strong physical component. Both in health and under certain pathological alterations.

Another of its main objectives is to explain the physical bases of diagnostic and intervention techniques that define modern Medicine, such as radiographic imaging, ultrasound imaging, the electrocardiogram, hemodialysis, or the audiogram.

Finally, the course provides physical bases useful to other basic courses such as Medical Physiology or Anatomy of the musculoskeletal system. And also to clinical specialties such as Pathophysiology, Diagnostic and Interventional Radiology, Cardiology, Pneumology, 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 through the cardiac cycle. Cardiac valves opening and closure pressures.

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. Laplace's law. Vascular compliance.

Seminar:
Collaborative team work to apply the acquired theoretical bases to understand different 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. V̇/Q ratio.

Respiratory resistance:
Airway resistance. Alveolar surface tension (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).

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.

Methodology

Theory classes (TE): Plenary lectures.

Seminars (SEM): Active, meaningful, collaborative peer-learning, to convert knowledge into competences. 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 also evaluated. One seminar associated with each of the 7 units.

Laboratory practices (PLAB): 6 sessions in which phenomena studied in theory classes and seminars are visualized and manipulated. Depending on the practice, work is carried out either in couples 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.
- Vision Optics (associated to Unit 5).
- Osmosis and dialysis (associated to Unit 6).
- 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.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Laboratory practices (PLAB)	19	0.76	1, 4, 5, 7, 6, 8
Seminars (SEM)	12	0.48	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

Assessment

Continuous evaluation

Three partial tests (P1, P2, and P3). Each of the partial grades will be composed by:

- 10% the active participation, including the individual results report for each of the laboratory practices at the end of the session. In the case of second-year students who participated in the lab practices on the previous year, participation is optional. If you choose not to repeat them, the participation corresponding to the immediately previous year will be counted.
- 90% an objective multiple choice test, to evaluate the integration of theoretical knowledge, and the acquisition practical competences acquired in the seminars and laboratory practices. Each question will propose 4 answers, of which 1, 2 or 3 may be true; erroneous answers will be subtracted proportionally.

The final mark will be calculated acording to the following proportion: P1 (36%) + P2 (34%) + P3 (30%).

Partials must score 4.5 or higher (mark including exam and the corresponding lab practices) to contribute to the global average.

To pass the course, the result of the weighted average must be equal to or higher than 5.0 (mark including exam and the corresponding lab practices).

Referral test

In the event of not passing the course by means of continuous evaluation, a referral test will be available to reevaluate the exam/s for those partials with a grade lower than 4.5 (mark including exam and the corresponding lab practices).

Please notice that, according to the School of Medicine evaluation regulations, to participate in the referral test/s, the student must have participated in at least two of the three partial tests.

The referral tests will consist of objective multiple-choice tests, with the same format and objectives as the partial tests.

To pass a referral test, the score must be equal or greater than 4.5 (mark including exam and the corresponding lab practices).

To pass the course after the referral tests, the global average must reach a minimum grade of 5.0 (mark including exam and the corresponding lab practices).

Students with partial grades equal to or greater than 4.5 (mark including exam and the corresponding lab practices), but with an overall average lower than 5.0 (mark including exam and the corresponding lab practices), may recover the partial or partials of their choice. The choice must be communicated ahead of time to the coordinator. In this case, the grade will always be the one from the last exam/s.

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.

Non-assessable student

According to UAB regulations, the student who has participated in evaluation activities accounting for 4 or more points (40%) of the global mark, cannot qualify as 'not assessable', thus extinguishing their course registration rights.

Exam marking review

After each test, a period will be announced for the individual reviewing of the markings.

Proof of participation

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

Misconduct

In the event of student misconduct (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.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Partial 1- Objective multiple choice tests to evaluate theoretical and practical knowledge, and reasoning and problem solving competences, Units 1, 2 and 3, lab practices 1 and 2.	36%	3	0.12	4, 7, 6, 8, 11
Partial 2- Objective multiple choice tests to evaluate theoretical and practical knowledge, and reasoning and problem solving competences, Units 4 and 5, laboratory practices 3 and 4.	34%	2.5	0.1	4, 7, 6, 8, 11
Partial 3- Objective multiple choice tests to evaluate theoretical and practical knowledge, and reasoning and problem solving competences, Units 6 and 7, laboratory practices 5 and 6.	30%	2	0.08	4, 7, 6, 11
Written reports - Laboratory practices results.	10%	3	0.12	1, 2, 3, 4, 5, 6, 8, 9, 11, 10

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.