Universitat Autònoma de Barcelona

2022/2023

Biophysics

Code: 102962
ECTS Credits: 7

Degree	Type	Year	Semester
2502442 Medicine	FB	1	A

Contact

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Use of Languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: No
Some groups entirely in Spanish: No

Teachers

David Garcia Quintana
Josep Bartomeu Cladera Cerdà
Patricia Carolina Gutierrez Neira
Alex Peralvarez Marin
Maria Isabel Marin Garcia
Nuria Benseny Cases

Prerequisites

To profit the most of the course, the student should have the theoretical knowledge and the problem-solving competences 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 or hemodialysis.

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

BLOCKS:

- Biomechanics of the musculoskeletal system (Unit 1).
- Physical bases of organ and systems function (Unit 2 circulatory, Unit 3 respiratory, item 5 vision, Unit 7 voice and hearing).
- Physical bases of radiation and radioactivity, and medical applications (Unit 4).
- Physico-chemistry of the molecular cellular or tissular systems: diffusion phenomena, osmosis, dialysis (Unit 6).

PROGRAM:

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. The basic cardiac cycle.

Viscous resistance and Poiseuille equation:
Blood viscosity. 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:
The studied theoretical bases will be applied to work different medically relevant casesand situations. Presentation of the physical bases of echocardiography and the electrocardiogram.

Unit 3. BIOPHYSICS OF RESPIRATION

Ventilatory mechanics:
Lung volumes and capacities. Continuity equation. Pressures involved in ventilation. The basic respiratory cycle. Pulmonary compliance.

Partial pressures and alveolar exchange:
Partial pressure. Inspired air conditioning. Alveolar diffusion. Fick's law. P/F ratio. Blood oxygenation in health and limitations in pathological alterations. V̇/Q ratio.

Respiratory resistance:
Airway resistance. Viscous resistance. Alveolar surface tension (Laplace's law) and pulmonary surfactant.

Seminar:
The studied theoretical bases will be applied to work different medically relevant cases and situations. 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

The eye as an optical system:
Optical parameters of the eye. Lens and accommodation mechanisms. Maximum power and minimum power. Near point and remote point. Amplitude of accommodation. Presbyopia.

Formation of images on the retina:
Anomalies in the formation of images. Ametropias: myopia, farsightedness. Correction of the different ametropias. Astigmatism.

Visual acuity:
Variation of visual acuity on the retina.

Visual photoreceptors and colour vision:
Visual photoreceptors in the retina. Chromatic vision and alterations.

Seminar:
Tools to interpret the basic information in the optical evaluation of vision will be provided. We will understand, for example, what a prescription "VL UD -1.5" means and what would be, in this case, the furthest distance at which the eye could focus on objects without wearing corrective lenses.

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.

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 loss. 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 thevocal 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 learning, among equals, to convert knowledge into competences. Study and discussion of scenarios, cases and problems of medical interest. Work in collaborative teams of 4-5 students. Before attending the face-to-face session, it is essential to carry out the preparatory work commissioned by the corresponding instructor. In some cases, aspects not covered in the theory classes (albeit equally evaluated) will also be addressed. One seminar associated with each theme, in some cases lasting 1 hour and in others 2 hours.

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.
- Model of the systemic vascular circulation.
- Physics of medical ultrasound.
- Vision Optics.
- Osmosis and dialysis.
- Voice and hearing.

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)	18.5	0.74	1, 4, 5, 7, 6, 8
Seminars (SEM)	10	0.4	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	2	0.08	1, 4, 7, 6, 8, 9
Type: Autonomous			
Study	61.5	2.46	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	40	1.6	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 and results report of the corresponding laboratory practices. 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 (30%) + P2 (40%) + 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 evaluate those partials with a grade lower than 4.5 (mark including exam and the corresponding lab practices).

To participate in the referral test/s, the student must have participated in at least two of the three partial tests.

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

In the event of taking the final exam for the whole course (P1, P2, and P3), a grade equal to or higher than 5.0 (mark including exam and the corresponding lab practices) must be reached to pass the course.

The referral tests will be objective multiple-choice tests, with the same format and objectives than the partial tests.

Students with partial grades equal to or greater than 4.5 (mark including exam and the corresponding lab practices), but with an overall average of less than 5.0 (mark including exam and the corresponding lab practices), may recover the partial or partials of their choice. In that case, the grade will always be the one from the last exam/s. Again, to pass the course the global average must reach a minimum grade of 5.0 (mark including exam and the corresponding lab practices).

Students with an overall grade equal to or higher than 5.0 from continuous assessment, 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. ")

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 her/his course registration rights.

From the second registration:

Students in their second or later registration may opt to directly take a final test covering all the course, the same day as the referral tests for the rest of students. To be eligible, they must not have taken any of the three partial exams earlier in the academic year. Such choice involves waiving the option to later take a referral test.

Exam marking review:

A time will be announced after each test to review the markings. The tutorials will be individual.

Proof of participation:

If necessary for empoyment-related reasons, the student may request a document certifying her/his participation inthe different evaluation activities. The request mustbe sent by mail to the course coordinator.

Misconduct:

In the event that a student undergoes misconduct (copy 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 and 2.	27%	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 3, 4 i 5.	36%	3	0.12	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.	27%	3	0.12	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

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

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: 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 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: Nociones de Fisicoquímica para Estudiantes de Medicina. R. Segura (1987). Ed. Salvat.

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 et al. (2013). Elsevier-Masson.
e-book:
https://bibcercador.uab.cat/permalink/34CSUC_UAB/1c3utr0/cdi_askewsholts_vlebooks_9788445823958

Software

Praat software for the analysis of sounds in auditory laboratory work.