Introduction to Biophysics

Code: 100165
ECTS Credits: 5

2024/2025

Degree	Type	Year
2500097 Physics	OT	3

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Teachers

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Teaching groups languages

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Prerequisites

It is advisable to have some general knowledge aon chemistry and biology, at a high school level.

The fields of physics most employed during the course will be Thermodynamics, Elasticity, Statistical Mechanics Electricity and Magnetism. So that, it is advisable to have followed courses on these topics in the previous years of the degree. In particular, students should have followed courses on theor second year the courses on 'Electromagnetism' and 'Matter Structure and Thermodynamics'. Regarding Statistical Mechanics, the present course can be done in parallel to Thermodynamics and Statistical Mechanics" (TerMec), as the applied perspective here complements the theoretical formalism which is developed in TerMec.

Objectives and Contextualisation

This course tries to provide a panoramic, but not exhaustive, introduction to biophysics. The main goal is that physics students have a first touch of physical analysis of problems that lie at the fontier with biology (and, often, with biochemistry), and become aware of the richness of problems in biology for which the tools and methods from physics are extremely worthy. Likewise, the course introduces several ideas at a basic level that can help the students to face in the future more advances courses related to biology, biotechnology, bioinformatics or complex systems.

Competences

- Act with ethical responsibility and respect for fundamental rights and duties, diversity and democratic values.
- Apply fundamental principles to the qualitative and quantitative study of various specific areas in physics
- Be familiar with the bases of certain advanced topics, including current developments on the parameters of physics that one could subsequently develop more fully
- Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, and before both specialist and general publics
- Develop the capacity for analysis and synthesis that allows the acquisition of knowledge and skills in different fields of physics, and apply to these fields the skills inherent within the degree of physics, contributing innovative and competitive proposals.
- Make changes to methods and processes in the area of knowledge in order to provide innovative responses to society's needs and demands.
- Take account of social, economic and environmental impacts when operating within one's own area of knowledge.
- Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
- Use mathematics to describe the physical world, selecting appropriate tools, building appropriate models, interpreting and comparing results critically with experimentation and observation
- Work independently, have personal initiative and self-organisational skills in achieving results, in planning and in executing a project

Learning Outcomes

1. Apply the power-cord model to the description of the shape and speed of action potential in excitable membranes.
2. Calculate Nernst's potential in physical and biological systems.
3. Communicate complex information in an effective, clear and concise manner, either orally, in writing or through ICTs, in front of both specialist and general publics.
4. Correctly apply the equations of passive and active transport to the propagation of nerve signals in excitable membranes.
5. Describe the bases to synchrotron radiation and its application to protein structure.
6. Describe the basic ideas of learning in neural networks and the principal morphological and functional characteristics of the brain.
7. Describe the basic steps in protein synthesis and the genetic code.
8. Describe the fundamentals of certain medical imaging techniques (MRI, PET, CT).
9. Describe the principal basic techniques of medical physics.
10. Describe the principal unresolved problems in biophysics (protein folding, physical sequencing of DNA, the physical bases of genetic and epigenetic code, molecular motors, neural networks).
11. Develop an understanding of the bases to biomedical observation techniques (electrocardiography, electroencephalography and magnetoencephalography).
12. Distinguish the fields of application for different types of microscope (optical, electronic, tunneling or atomic force).
13. Establish the basic concepts of physics membranes and active and passive transport, and apply these to the action potential in the nervous system.
14. Establish the basic physical aspects of proteins and nucleic acids.
15. Explain the explicit or implicit code of practice of one's own area of knowledge.
16. Identify situations in which a change or improvement is needed.
17. Identify the social, economic and environmental implications of academic and professional activities within one's own area of knowledge.
18. Model various biological processes (growth of tumors, cardiac excitation waves, learning in neural networks, immune system).
19. Use critical reasoning, show analytical skills, correctly use technical language and develop logical arguments
20. Work independently, take initiative itself, be able to organize to achieve results and to plan and execute a project.
21. Work on problems of the dosimetry of ionizing radiation and its biological effects for subsequent training in medical physics.

Content

Program

1. Chemical foundatiosn of biophysics.

2. Physics of macromolecules.
3. The central dogma of biology.
4. Introduction to cellular physics.
5. Introduction to neurophysics.
6. Morphogenesis, evolution and ecosystems.
7. Biomechanics and bioenergetics.

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Practical classes	14	0.56	1, 2, 4, 18
Theoretical classes	27	1.08	5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 19, 21
Type: Autonomous			
Mentoring sessions	5	0.2	18
Project and autonomous exercises	18	0.72	1, 2, 10, 18, 21
Study	53	2.12	5, 6, 7, 8, 9, 10, 11, 12, 13, 14

We start the course by reviewing the essential properties of macromolecules, centering our attention on proteins and DNA (their elements, structure, and mechanical and electrical properties). Then we study some physical aspects of macromolecules, focused on molecular pumps and engines. At the cell level, we introduce basic ideas about metabolism, and the main structural and transport properties of the cell membrane, with a special emphasis given to the behavior of the neuronal system (individual neurons, networks, and the brain). Finally we introduce several basic ideas about population dynamics and evolution, and the role that physics play in the latter (in particular how evolution have found solutions to overcome the physical difficulties to the movement or to the energy income of living organisms).

Les classes de teoria utilitzaran parcialment una metodologia d'aula invertida en la qual cada setmana es passarà materials previs (lectures en pdf o presentacions en vídeo) de la temàtica que després es tractarà a classe, i es plantejaran algunes qüestions tipus test per fer-ne un seguiment de l'activitat. Aquests material i lectures, a més, serviran com a base per a escollir el treball de l'assignatura, que tindrà un format doble (escrit i video).

The theoretical part of the course will be partially based on a flipped-classroom methodology. Every week the students will be given access to previous materials (readings in pdf or presentations in video format) as an introduction to the topic that will be discussed and presented in the class. In order to make a follow-up of this activity, some quizes will be made available on Moodle. Also, these materials and readings will be used as the starting point to choose the topic of the main assigment of the course, which will have a double format (first a written report, and then an oral presentation in video format)

At the end of each theme some optional exercises will be proposed for the students to check if they have satisfactorily understood the essential concepts presented.

Practical lessons will be used to discuss in group and solve the exercises from the main list of the course.

We will employ 15 minutes from the last session of the course to let the students answer the instituional survey about the course.

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
1st part of the project: Infography	10/100	1	0.04	3, 10, 19, 20
2nd part of the project: Video presentation	10/100	2	0.08	3, 15, 17, 19, 20
Partial exam 1	35/100	2	0.08	1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 18, 19, 21
Partial exam 2	40/100	2	0.08	1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 18, 21
Quizes about previous readings	5/100	1	0.04	3, 15, 16, 17, 19, 20

1st partial exam: It will cover the themes 1-3 of the course. It will represent a weight of 35% over the final grade.

2nd partial exam: It will cover the themes 4-7 of the course. It will represent a weight of 40% over the final grade.

Quizes: All previous materials and readings will have a quiz associated that the students have to complete before the classroom session. These quizes will represent a weight of 5% over the final grade.

Assignments: Using the previous materials and reading as a starting point, the student will choose a topic related to the course and will firstt prepare a written report (that will represent a 10% of the final grade). Once this report has been corrected, they will prepare from it an oral presentation in video format. This presentation will represent a 10% of the final grade and will be used to evaluate the learning outcomes related to synthesis and comunicative skills of the students (they will have available equipments and techincal assistance for recording their presentations).

To pass the course it is necessary to have a global grade of 5 (over 10) and having obtained a minimum grade of 3,5 in each of the two partial exams.

Those students that have taken the partial exams but have not obtained a minimum grade of 3,5 (or those who have not obtained an average grade of 5) have the option of a retake exam.

The quizes and assigments of the course will not have a retake option.

ONE-ASSIGNMENT EVALUATION:

Thjose students that decide to choose a one-assignment evaluation will take a final exam covering all the contents corresponding to the first and the second partial exams (this will represent a 80% of the final grade), and will present both assignment 1 and 2 together (this will represent the other 20% of the final grade). Since they are specifically dessigned for an on-going evaluation, the quizes will not be considered as an evaluation activity in this case.

To pass the course it will be necessary to obtain a minimum grade of 3,5 in the final exam, and an average global grade of 5 or higher. If this is not the case, the student still have the option of a retake exam (the assignments will not have a retake option).

Bibliography

Main references

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1987

B. B. Benedek and F.M.H. Villars, *Physics, with illustrative examples from biology* (3

vols), Addison-Wesley, 1979

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M. Ashrafuzzaman. Introduction to Modern Biophysics. CRC Press, 2024

Software

This course does not require the use of any specific software.

Only for the presentation in video, software of broacasting and edition (OBS; Shotcut, ...) will be necessary.

Language list

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	1	Catalan/Spanish	first semester	morning-mixed
(TE) Theory	1	Catalan	first semester	morning-mixed