COURSE LAYOUT

1. GENERAL

SCHOOL	APPLIED BIOLOGY & BIOTECHNOLOGY		
DEPARTMENT	BIOTECHNOLOGY		
STUDY LEVEL	*Undergraduate*		
COURSE CODE	233	**SEMESTER**	3rd
COURSE TITLE	Physics of Life		

INDEPENDENT TEACHING ACTIVITIES	**WEEKLY TEACHING HOURS**	**ECTS**
LECTURES	3	3,25
PRACTICAL EXERCISES	2	1,75
TOTAL	5	5

COURSE TYPE	Scientific Specialization
PREREQUISITES	Physics, Biochemistry of biomolecules
LANGUAGE	Greek
IS THE COURSE OFFERED for ERASMUS STUDENTS?	NO
COURSE WEB PAGE	https://oeclass.aua.gr/eclass/courses/BIOTECH151/

2. LEARNING OUTCOMES

Learning Outcomes

The course aims to introduce students to the basic concepts of the interdisciplinary field of Biological Physics that offers an overview of Physics related to Biology and addresses one of the greatest challenges of the 21st century: the meeting of Physics with Biology. The aim of the course is to deepen students' understanding of the fundamental laws of Physics and how they interpret and also set limitations on the evolution of biological phenomena. The course offers students an overview of key physics concepts related to biological applications ranging from the properties of proteins and processes in the cell. It also examines general issues of common interest, such as reductionism, determinism, randomness, and the balance between order and disorder, where the Physical view is often misinterpreted. There are descriptive sections that are sufficient for understanding general ideas and sections that are more detailed for a deeper understanding of ideas expressed in terms of mathematical equations.

Upon successful completion of the course, the student

(1) will have delved into concepts of Physics which are a necessary background in the study of biological phenomena.

(2) will be able to use simple mathematical models to express Physical Laws but also distinguish the abstract nature of Physics models from more complex biological systems

(3) will be able to carefully implement the Physical Laws to the study of biological systems, understanding the usability and the possibilities of their application in such complex systems.

(4) will have realized the limitations that the Laws of Physics place on the evolution of biological phenomena and he/she will have immersed him/herself in concepts such as Epimerocracy, Reductionism, determinism and randomness.

(5) will have been introduced to an interdisciplinary field of great interest and perspective for the continuation of his/her undergraduate and postgraduate studies but also for the research and development of innovative biotechnological applications.

General Competences

By critically studying the fundamental laws of physics that interpret but also restrict the biological procedures, facing the questions and challenges arisen from the physics-biology interdisciplinary field, with theoretical problems, practical exercises and calculated simulations, the students develop skills related to:

- Searching, analyzing, synthesizing data and information by using essential technologies
- Adaptation to novel and diverse challenges
- Decision making
- Independent and teamwork
- Exercising criticism and self-criticism
- Work in a multidisciplinary environment
- Promotion of free, creative and inductive thinking

3. COURSE CONTENT

I. THEORY

INTRODUCTION Differences and points of contact between Physics and Biology. The Role of Physical Laws in Biological Processes. Microcosm – Macrocosm. Recognition of the different degrees of organization of matter. Reductionism – Determinism – Randomness – Complexity. Physical Sizes – Units – Scales.

The Significance of Size in the Phenomenon of Life. Mass-Energy transfer in thermodynamic systems. Allometry and size scale. Allometric behavior in basal metabolic rate. The Significance of Size in the Phenomenon of Life, Law of the Square-Cube. Thermodynamic systems. Equilibrium vs steady state. Mass Exchange: Diffusion, Energy Balance on Earth.

Statistical thermodynamics. Basic hypotheses, microstates - macrostates and statistical entropy. Statistical entropy and thermodynamic entropy (Carnot cycle, reversible irreversible changes). 2^{nd} Thermodynamic law and the direction of time. Statistical weights and the distribution function. Energy distribution. Examples – applications in biological systems.
Stochastic dynamics – Applications. Stochastic Processes. Random Walks. Basic equations. Brownian motion. Diffusion and continuous stochastic processes. Diffusion in cells.

Electric Forces and Fields. Electric charge and charge maintenance. Coulomb's Law. Conductors and Insulators. Electric fields. Principles of electrophoresis: Macromolecular charges in solution. Modern methods of electrophoresis.

Electric Potential Energy and Electric Potential. Intermolecular non-covalent interactions. Electric potential energy. Electric dipoles and charge distributions. Mapping the electrical potential of the human body: Heart, muscles and brain. Atomic and molecular no-covalent interactions. Static electrical properties inside matter.

Dielectric medium, Capacitors and Membranes. Electric Current and Electric Membrane Currents. Capacitors and membranes. Membrane channels. Electric current and resistance. Applications of Ohm's law and electrical measurements. Electric membrane currents. Overview of Nerve Structure and Function: Technical Measurements. Electrical properties of neurons.

Magnetic Fields - Electromagnetic Induction and Radiation. Magnetic fields and forces. Forces and torque on a magnetic dipole. The Stern-Gerlach experiment and electron spin. Magnetic properties of materials. Creating magnetic fields. Magnetic moment of the nucleus and Nuclear Magnetic Resonance. Ampere's law. Electromagnetic induction and Faraday's law. Maxwell's equations – Electromagnetic radiation.

Quantum Mechanics. Overview of quantum theory. Fundamentals of quantum mechanics. How life is affected by quantum phenomena?

Assignments

1. Allometric Equations
2. Energy Balances
3. Statistical Physics
4. Diffusion
5. Electric forces and fields
6. Electric potential energy and Electric potential
7. Electric current, Capacitors, Membranes

Practical Exercises

1. Brownian motion - Diffusion
2. Electric charges and fields
3. Polarity of molecules,
4. Salting out - Intermolecular Interactions
5. Capacitors
6. Nernst-Goldman Membrane Potential Equation - Propagation of electrical signal in neurons
7. Optical Tweezers

4. TEACHING and LEARNING METHODS - Evaluation

TEACHING METHOD.	In suitably equipped teaching and laboratory rooms
USE OF INFORMATICS and COMMUNICATION TECHNOLOGIES	Use of powerpoint presentations and Phet simulations in lectures, use of specialized software and videos, use of open e-class platform to inform, educate and communicate with students
TEACHING ORGANISATION	see table below

Activity	***Work Load***
Lectures	39
Practical Exercises	14
Assignments	30
Independent study	40
Final Exam	2
Course total (25 hours of student workload per ECTS)	***125 (5 ECTS)***

STUDENTS EVALUATION	I. Theory: Seven (7) optional assignments (up to 10% of the final grade) Written final examination comprising: multiple choice questions, problem solving and short answer questions (40 - 50 % of the final grade). II. Practical Exercises: Up to seven practical exercises. Obligatory physical presence in the lab and written assignments (successful completion of the lab requires an average grade of the assignments equal or greater than 5/10). 50% of the final grade.

5. BIBILIOGRAPHY

1. College Physics I, Freedman Roger A., Ruskell Todd G., Kesten Philip R., Tauck David L.,3rd

edition, ISBN 978-0716797913

2. Physics of the Life Sciences by Jay Newman, ISBN: 978-0-387-77259-2

3. Biological Physics: Energy, Information, Life; Philip Nelson; (W. H. Freeman), ISBN 978-0716743729

4. Physical Biology of the Cell, R. Phillips, J. Kondev and J. Theriot (Garland Sci., New York, 2009)

5. *What is Life?*: With Mind and Matter and Autobiographical Sketches by Erwin Schrodinger