COURSE DETAILS

"PHYSICS IN MEDICINE"

SSD FIS/07*

DEGREE PROGRAMME: ENGLISH COURSE IN MEDICINE AND SURGERY

ACADEMIC YEAR2026-27

GENERAL INFORMATION–TEACHER REFERENCES

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GENERAL INFORMATION ABOUT THECOURSE

INTEGRATED COURSE (IF APPLICABLE): PHYSICS IN MEDICINE
TEACHINGLANGUAGE: ENGLISH
YEAR OF THE DEGREE PROGRAMME(I, II, III): I
SEMESTER (I, II, ANNUAL): I
CFU: 5

REQUIRED PRELIMINARY COURSES (IF MENTIONED IN THE COURSE STRUCTURE "REGOLAMENTO")

none

PREREQUISITES (IF APPLICABLE)

Mathematical functions and their graphic representation. Just the concepts of the derivative and the integral of a function and their geometrical interpretation. The main physical quantities and their unit of measurements. Mechanics: Basic Statics, Kinematics and Dynamics.

LEARNING GOALS

The first objective is methodological: the goal is to train students in understanding and interpreting physical phenomena involved in Life Sciences and developing in the student analysis/synthesis skills needed for their educational program and during their professional life. Attention is dedicated to the decomposition of a complex phenomenon into simpler steps, by identifying the fundamental parameters determining its dynamics, and by evaluating the applicability of the Physics laws on the base of the assumed hypotheses.

EXPECTED LEARNING OUTCOMES (DUBLIN DESCRIPTORS)

Knowledge and understanding

Students are expected to know and interpret fundamental Physics laws, to illustrate and explain these laws within their natural frame, and to provide examples of these laws taken from Life Sciences, thus demonstrating the capability to correctly determine the physical mechanisms at the basis of the proposed phenomena.

Applying knowledge and understanding

Students are expected to:

• Determine and interpret the physical quantities at the basis of biochemical transformations through Thermodynamics Principles.

• Apply the perfect gas laws to breathing mechanisms.

• Analyze and justify phenomena related to surface tension through the exerted inter-molecular forces in solids and liquids.

• Interpret the dynamics of blood circulation and breathing system in terms of models based on hydrodynamics laws.

• Explain wave properties and features. Utilize them to understand and interpret the functions of listening system and vision.

• Describe how optical devices work.

• Describe electric and magnetic phenomena and understand their connection with electrophysiology and biomedical instrumentation.

• Describe ionizing radiations and illustrate methods for their generation and attenuation.

COURSE CONTENT/SYLLABUS

THERMODYNAMICS

Thermodynamical system and state. Zero principle of Thermodynamics. Thermal dilatation. Temperature scales. Calorimetry. Thermodynamical work. Thermodynamical transformations. First principle of Thermodynamics. Internal energy. Perfect gases and their transformations. State equation of perfect gases. Second principle of Thermodynamics. Thermal engines. Carnot's cycle: efficiency. Entropy. Thermodynamical potentials.

GASES AND GAS MIXTURES

Microscopic model of perfect gas: pressure, temperature, internal energy. Freedom degrees of a molecule. Equipartition of energy. Partial pressure and Dalton's law. Henry's law. Pressure and solubility of breathing gases. High pressure breathing.

DYNAMICS OF LIQUIDS
Continuity equation. Bernoulli theorem: consequences and applications. Flux by parallel planes: Newton's law: shear stress, velocity gradient, viscosity. Newtonian liquids. Flux in a cylindrical pipe: Poiseuille's law. Comparison with Ohm's law: hydrodynamical resistance. Laminar and turbulent flux: Reynolds number. Variation of Reynolds number in the human circulatory system. Aorta flux. Blood velocity and pressure in human circulatory system. Aortic pressure measurements. Non-Newtonian liquids Differential viscosity. Cardiac work.

WAVE PHENOMENA
Wave motions. Description and parameters of a wave. Superposition principle and Fourier's theorem. Sound wave nature and velocity in different media. Sound intensity and decibel scale. Sound pressure.

GEOMETRICAL OPTICS
Geometrical optics. Reflection and refraction. Refraction index. Total reflection. Critical angle. Light dispersion. Plane mirror. Spherical diopter. Thick lens. Thin lenses. Dioptric power. Diverging and converging lenses. Magnification. Thin lenses systems. Human eye: structure and optical media. Simplified eye. Light ray path in human eye. Accommodation power. Human eye refractive disorders and their correction. Diffraction by a circular hole. Eye spatial resolution.

ELECTRICITY
Electric charge. Conductor and insulators. Electrostatic induction. Coulomb's law, electrical field and potential. Gauss theorem. Electrical capacitance. Series and parallel capacitors. Electric direct current: Ohm's law. Series and parallel of resistors. Magnetic effects of electric current: Biot's and Savart's law. Ampere's law. Lorentz's law. Tesla.

BASIC IONIZING RADIATION
Electromagnetic radiation and photons. Atomic models. X-ray and their production. Characteristic radiation. X-radiation absorption, half value layer. Atomic nucleus. Nuclear forces. Mass defect. Nuclear stability. Radioactivity. Radioactive decay law. Activity. Alfa, Beta and Gamma decay. Physical and biological half-life.

READINGS/BIBLIOGRAPHY

College Physics, OpenstaxCollege Rice University, Houston Texas USA (ebook available for free at https://cnx.org/contents)
Other supports for teaching materials: Slides of FDA and IDA (https://www.docenti.unina.it - Search for ALTUCCI CARLO)

TEACHING METHODS

Lectures and exercises. A) Lectures for approx. 75% of total hours; B) practical exercises for approx. the remaining 25% of total hours. Some online material is used besides the recommended textbook available online and the teacher's presentations.

EXAMINATION/EVALUATION CRITERIA

*For **integrated courses**, this field should encompass all modules, with indication of the relative weight of each module on the final mark. For integrated courses, this field should be coordinated by the reference teacher for the course.*

a) Exam type:

Examtype	
Written and oral	X
Only written	
Only oral	
Project discussion	
other	

In case of a written exam, questions refer to: (*)	Multiple choice answers	X
	Open answers	
	Numerical exercises	

(*) multiple options are possible

b) Evaluation pattern:

- Test of multiple choice questions concerning topics included in formal lectures and other learning activities

- Oral exam concerning topics included in formal lectures and other learning activities
Passing the written test is obligatory before accessing the oral exam. Typically, but non-necessarily, the final mark increases after the oral exam, compared to the initial mark of the passed written test.

CALENDAR of THE COURSE LESSONS

Week	Day		Timetable	Module	Topics	Teacher
1	Wednesday	28/10/2026	15.30 - 17.05	Thermodynamics	System and thermodynamic state. Zeroth law of thermodynamics. Thermal expansion. Thermometric scales. Calorimetry. Equilibrium of a thermodynamic system.	Altucci
	Thursday	29/10/2026	13.00 - 14.35	Thermodynamics	Heat transfer mechanisms. Conduction. Fourier's law. Convection. Irradiance: Black body. Law of Wien and Stefan-Boltzmann	Altucci
	Friday	30/10/2026	13.00 - 13.45	Thermodynamics	Thermodynamic transformations. Work in thermodynamics.	Altucci
2	Wednesday	04/11/2026	15.30 – 17.05	Thermodynamics	the first principle of thermodynamics. Internal energy. Ideal gases and their transformations. State Equation of ideal gases.	Altucci
	Thursday	05/11/2026	13,00 – 14,35	ADI	First approach with Problem Solving	Altucci
	Friday	06/11/2026	13.00-13.45	Thermodynamics	2nd law of thermodynamics. Entropy. Thermal machines. The Carnot cycle: yield.	Altucci
3	Wednesday	11/11/2026	15.30 - 17.05	Thermodynamics	Microscopic model of an ideal gas: pressure, temperature, internal energy. Degrees of freedom. Equipartition of energy	Altucci
	Thursday	13211/2026	13.00 - 14.35	Thermodynamics	Partial pressure and Dalton's law. Henry's law. Pressure and solubility of respiratory gases.	Altucci
	Friday	13/11/2026	13,00 – 13,45	ADI	Problem Solving	Altucci
4	Wednesday	18/11/2026	15.30 - 17.05	Liquids	Ideal liquids: hydrostatics. Stationary motion of a liquid, flow rate. Bernoulli's theorem: consequences and applications in Medicine.	Altucci
	Thursday	19/11/2026	13.00 - 14.35	ADI	Problem solving on liquids	Altucci

	Friday	20/11/2026	13,00 – 13,45	Liquids	Newtonian liquids. Simple sliding: Newton's law, tangential force, speed gradient, viscosity. Laws of hydrostatics.	Altucci
5	Wednesday	25/11/2026	15.30 - 17.05	Liquids	Flow in a cylindrical duct. Poiseuille's law Comparison with Ohm's law: hydrodynamic resistance. Laminar motion and turbulent motion.	Altucci
	Thursday	26/11/2026	13.00 - 14.35	ADI	Laboration/exercises	Altucci
	Friday	27/11/2026	13.00 - 13.45	Liquids	Reynolds number and circulatory system. Flow rate of the aorta. Blood speed and pressure in the human circulatory system.	Altucci
6	Wednesday	02/12/2026	15.30 - 17.05	Liquids	Measurement of aortic pressure. Non-Newtonian liquids: Cardiac work.	Altucci
	Thursday	03/12/2026	13.00 - 14.35	Liquids	Surface phenomena: experimental evidence. Intermolecular forces. Surface tension: definitions	Altucci
	Friday	04/12/2026	13.00 – 14.35	ADI	Laboration/exercises	Altucci
7	Wednesday	09/12/2026	15.30 - 17.05	Liquids	Capillarity: contact angle, Jurin's law. Laplace's law for separating surfaces of different shapes. Gaseous emboli	Altucci
	Thursday	10/12/2026	13.00 - 14.35	Waves and Acoustics	Wave motions, description and parameters of a wave. The superposition principle.	Altucci
	Friday	11/12/2026	13.00 - 13.45	ADI	Laboration/exercises	Altucci
8	Wednesday	16/12/2026	15.30 - 17.05	Waves and Acoustics	Nature of sound waves and their propagation speed in the various media. Sound intensity and decibel scale. Sound pressure.	Altucci
	Thursday	17/12/2026	13.00 - 14.35	Waves and Acoustics	Stationary sound waves on strings. Doppler effect. Intensity, pitch and timbre.	Altucci
	Friday	18/12/2026	13.00 - 13.45	ADI	Laboration/exercises	Altucci
9	Thursday	07/01/2027	13.00 - 14.35	Optics	Ray optics. Reflection and refraction. Refractive index. Total internal reflection. Light dispersion. Flat mirror. Spherical diopter. Thin lens.	Altucci
	Friday	08/01/2027	13.00 - 13.45	ADI	Laboration/exercises	Altucci
10	Wednesday	13/01/2027	15.30 - 17.05	Optics	Diverging and converging lenses. Magnification. Thin multi-lens system.	Altucci
	Thursday	14/01/2027	13.00 - 14.35	Electricity and Magnetism	The human eye: structure and optical media. Simplified eye model. Path of light rays in the human eye. Accommodative power. Refractive defects of the eye and their correction. Eye resolution.	Altucci
	Friday	15/01/2027	13.00 - 13.45	ADI	Laboration/exercises	Altucci
11	Wednesday	20/01/2027	15.30 - 17.05	Electricity and Magnetism	Electric charges. Conductors and insulators, capacitance.	Altucci

	Thursday	21/01/2027	13.00 - 14.35	Electricity and Magnetism	Electric current. Resistance. Resistors in series and parallel. Magnetic field and electric current: Biot/Savart's law. Ampere's law. Lorentz law.	Altucci
	Friday	22/01/2027	13.00 - 13.45	ADI	Laboration/exercises	Altucci
12	Wednesday	27/01/2027	15.30 - 17.05	Electromagnetism	Motion of a charge in a uniform electric field. Alternating current. loops: Resistive, capacitive and inductive loop. The RLC loop: the impedance.	Altucci
	Thursday	28/01/2027	13.00 - 14.35	Radiations	Electromagnetic radiation and photons. Main features and spectrum of electromagnetic waves. Atomic models. X-rays and their production. Characteristic radiation. X-ray absorption, hemivalent thickness.	Altucci
	Friday	29/01/2027	13.00 - 13.45	ADI	Laboration/exercises	Altucci
13	Wednesday	03/02/2027	15.30 - 17.05	Radiations	The atomic nucleus. Nuclear forces. mass defect. Stability of nuclei. Radioactivity. Law of radiative decay Activity. Alpha, beta and gamma decay. Physical and biological half-life.	Altucci
	Thursday	04/02/2027	13.00 - 14.35	ADI	Final test.	Altucci