



Syllabus Master's Degree Course in Medicine and Surgery

PRINCIPLES OF THE HUMAN MATTER

First year, first semester (10 academic credits [CFU])

Teachers

Subject	Academic credits (CFU)	Lecturer
Applied physics	4	LANZANO Luca
Chemistry and biochemistry propaedeutics	6	LI VOLTI Giovanni

Learning outcomes

Subject	Learning outcomes
Applied physics	By the end of the course, students are expected to: • Demonstrate increased knowledge and understanding of the fundamentals of physics. • Acquire knowledge of fundamental physical laws and techniques applicable to the comprehension of physiological, biological, and medical processes. • Gain proficiency in basic concepts essential for the proper utilization of instrumentation relevant to the professional field.
Chemistry and biochemistry propaedeutics	By the end of the course, students are expected to: • Demonstrate increased knowledge and understanding of the fundamentals of inorganic and organic chemistry. • Acquire knowledge of fundamental chemical processes applicable to the comprehension of physiological, biological, and medical mechanisms. • Gain proficiency in basic concepts essential for the proper comprehension of biochemistry relevant to the professional field.

Prerequisites

Subject	
Applied physics	Topics from the Mathematics and Physics programs required for the admission exam, basic computer skills, and internet navigation knowledge.
Chemistry and biochemistry propaedeutics	Topics from the Mathematics and Chemistry programs required for the admission exam, basic computer skills, and internet navigation knowledge.

Course contents

Subject	
Applied physics	• INTRODUCTION: Physical quantities, units of measurement, significant digits, measurement error, scalar quantities and vector quantities, operations with vectors, components of a vector. • MECHANICS: One-dimensional and two-dimensional motion. Tangential and radial acceleration. Laws of dynamics. Examples of forces. Motion of rigid bodies. Moment of a force. Vector product. Barycenter. Equilibrium conditions. Levers. Statics of body joints. Examples of physiological levers. Hooke's law and Young's modulus. Fractures. Friction. Dynamics of circular motion. Centrifugal force. Work. Kinetic energy theorem. Conservative and non-conservative forces. Potential energy. Conservation of energy. Moment of inertia and rotational energy. Momentum. Elastic and inelastic shocks. • FLUID MECHANICS: Density and pressure in fluids. Stevin's law. Pascal's principle. Archimedes' principle and buoyancy. Continuity equation. Bernoulli's theorem. Viscous fluids. Laminar flow. Poiseuille's formula. Turbulent flow. Blood flow rate and velocity. Blood viscosity. Blood Pressure and resistance of vessels. Aneurysm and stenosis. Sphygmomanometer. Stokes' law. Viscous drag. Centrifuges. Cohesion. Surface tension. Laplace's law. Erythrocyte sedimentation rate, centrifugation. • THERMODYNAMICS: Thermometers and temperature scales. Thermal expansion of solids and liquids. Ideal gases. Elements of kinetic theory of gases. Heat and work. Specific vs latent heat. Heat transmission. Thermoregulation. Laws of thermodynamics. Molecular diffusion. • ELECTROMAGNETISM: Charge. Coulomb's law. Electric field. Field of an electric dipole. Uniform electric field. Electric potential. Capacity. Capacitors. Effect of dielectrics. Electric current. Ohm's law. Power dissipation and Joule effect. Resistors in series and in parallel. Electromotive force. RC circuit and pacemaker. Bioelectric phenomena. Action potential. Propagation of nerve impulses. Magnetic fields. Force acting on a charge. Solenoid. Electromagnetic induction. Faraday's law. AC generator. Transformer. Defibrillator. Effects of current. Nuclear magnetic resonance. • WAVES AND OPTICS: Wave phenomena. Acoustic Waves. Ultrasound and applications. Spectrum of electromagnetic waves. Effects on human health. Polarization. Law of Malus. Lasers and applications. Light reflection. Refraction of light. Snell's law. Light scattering. Total internal reflection. Optical fibers and endoscopes. Image formations from mirrors and lenses. Optical microscope.
Chemistry and biochemistry propaedeutics	• Fundamentals of the atomic structure, atomic particles and model with orbitals. • Radioactivity: characteristics of radiations and their biological effects. Stable and unstable isotopes and their importance in biology and medicine. Atomic properties, electronic configurations and Periodic Table. • Chemical bonding. Ionic, covalent, coordinative, hydrogen bond, Van der Waals forces. Chemical resonance. Geometry of simple molecules. Orbital hybridization. Coordination complexes and biological macromolecules (hemoglobin, cytochromes, vitamin B12, etc.).

- Chemical systematics: acidic and basic oxides, hydroxides, acids; salts neutral, acidic and basic peroxydes, hydrides. General characteristics and properties of the solid, liquid and gaseous state. Laws of ideal gases and their importance in breathing. State passages. Water state diagram. Solutions: water as a solvent. Molarity, normality, molality, molar fraction. Concentrations of some electrolytes in biological matrices. Colligative properties: cryoscopy, osmotic pressure and its biological meaning. Hypertonic, isotonic and hypotonic solutions and their use in medicine. Osmole concept. Electrolytes, dissociation grade, ionic strength.
- Chemical reactions. Kinetics and factors influencing the reaction velocity. Reaction order. Reaction energy and catalysis. Catalysis relevance in biology: an overview of enzymatic catalysis. Chemical equilibrium: law of the mass action. Principle of mobile equilibrium. Simple concepts on thermodynamics: enthalpy, entropy and free energy. Hess's law. Bioenergetics: coupled reactions, compounds with high energetic potential (ATP, GTP, etc.).
- Redox reactions: oxidation number, redox potential and its measurement; variation as pH function. Potentiometric measurement of pH. Redox reactions in live matter.
- Acids and bases: water as electrolyte, pH. Acidic and basic strength. Equilibria in solution: hydrolysis, pK, buffer systems. Titration curves of acids and bases, ampholytes. Importance of acid/base equilibrium in the organism. Solubility product.
- Colloidal solutions: characteristics, classification, methodology of study. Bioinorganic chemistry: fundamental notions on chemical compounds of elements of major biological interest: Na, K, Li, Ca, Mg, Cu, Mn, Fe, Co, H, O, C, N, S, P, Cl, Br.
- Organic chemistry: classification of the compounds on the basis of functional groups. Classification of the organic reactions. Isomerism. Structural cis-trans isomerism, tautomerism, optical isomerism (stereochemical series); isomerism relevance on the properties of biological and medical compounds.
- Electronic effects on organic molecules: inductive, mesomeric, steric. Electrophilic and nucleophilic reagents. Organic reactions: redox reactions; substitution reactions (S_N1 e S_N2); simple nucleophilic reaction of addition to carbonyl bond; electrophilic addition reaction followed by elimination reaction; electrophilic addition to alkenes and alkynes; electrophilic substitution reactions; orientation effects; polymerization reactions.
- Organic compounds: Alkanes, alkenes, dienes, alkynes, cycloaliphatic hydrocarbons; nomenclature, physical and chemical properties. Arenes: nomenclature, physical and chemical properties. Alkyl and aryl halogenides: nomenclature, chemical properties. Aliphatic and aromatic alcohols, mono and polyvalent: nomenclature, classification, chemical properties. Thioalcohols. Phenols, ethers and thioethers: nomenclature, classification, chemical properties. Aliphatic and aromatic amines: nomenclature, classification, chemical properties; quaternary ammonium salts, amino-alcohols, diamines.
- Test reactions. Aliphatic and aromatic aldehydes and ketones: properties; aldol condensation. Aliphatic and aromatic acids: chemical properties, inductive effect on the acidity; mono and polycarboxylic acids, saturated, unsaturated; malonic synthesis, oxyacids (lactides and lactones), chetoacids; (keto-enol tautomerism), enolphosphates. Acid derivatives: phosphoric

	esters; amides, anhydrides: simple, mixed, cyclic; nitriles hydrazides: chemical properties and text reactions; acyclic chlorides. Lipids: glycerides, fats, saponification; phospholipids and sphingolipids and their biological role. Aminoacids: electrolytic behavior; carbo-amidic bond. Peptides. Proteins and their structures. Glucides: nomenclature, solubility, classification; hexoses configuration, mutarotation, chemical properties; di- and polysaccharides; aminosugars. Heterocyclic compounds with 5 and 6 termini, aromatic rings, acidity (furan, pyrrole, thiophene, thiazole, imidazole, oxazole, pyridine, pyrimidine, purine, indole, chinoline, isochinoline, nicotinic acid, isonicotinic acid). Purinic and pyrimidinic bases: their tautomerism. Nucleic acids. Assays of organic compounds with biological relevance in the biochemo-clinical analyses.
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Assessment methods

Subject	Assessment methods
Applied physics	The assessment of acquired knowledge is conducted by an oral examination. The grade is expressed on a scale of thirty, up to a maximum of 30/30 cum laude (with honors). The final grade is determined by the weighted average of the scores obtained in the course subjects. The oral examination consists of an interview during which questions will cover at least three different topics from the course curriculum. The assessments aim to evaluate: i) the level of knowledge in the disciplines; ii) the ability to apply this knowledge to solve specific problems related to the disciplines (autonomous problem-solving); iii) clarity of expression; iv) proficiency in medical-scientific language. The assessment of learning can also be conducted remotely if the conditions necessitate it. For the assignment of the final grade, the following parameters will be considered: • Score 29-30 with honors: The student demonstrates an in-depth knowledge of the topics, promptly and correctly integrates and critically analyzes presented situations, independently solving even highly complex problems. They possess excellent communication skills and command medical-scientific language proficiently. • Score 26-28: The student has a good understanding of the topics, is able to integrate and critically and logically analyze presented situations, can fairly independently solve complex problems, and presents topics clearly using appropriate medical-scientific language. • Score 22-25: The student has a fair understanding of the topics, although it may be limited to the main areas. They can integrate and critically analyze presented situations, although not always in a linear fashion, and present topics fairly clearly with moderate language proficiency. • Score 18-21: The student has minimal knowledge of the topics, possesses modest ability to integrate and critically analyze presented situations, and presents topics sufficiently clearly, although their language proficiency may be underdeveloped. • Exam not passed: The student lacks the minimum required knowledge of the core content of the course. Their ability to use
Chemistry and biochemistry propaedeutics	

	specific language is minimal or nonexistent, and they are unable to independently apply acquired knowledge.
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Examples of common questions and/or exercises

Subject	Examples of common questions and/or exercises
Applied physics	• Equilibrium conditions • Examples of levers in the human body • Hooke's law and Young's modulus • Energy conservation • Stevin's law • Continuity equation and applications to blood flow • Bernoulli's theorem and application to blood flow • Poiseuille's law • Thermometers and thermal expansion • Latent heat and phase changes • Thermoregulation • Coulomb's law • Electric field and potential • Ohm's law • Action potential • AC generator • Ultrasound and applications • Spectrum of electromagnetic waves • Total internal reflection and applications
Chemistry and biochemistry propaedeutics	• pH calculation • Chemical compound nomenclature • Chemical reaction description • Redox reaction balance • Colligative properties • Atomic structure • Definition for acids and bases

Reference texts

Subject	Textbooks
Applied physics	• Bacchetta, Scannicchio – Introduction to Medical Physics – CEA Any additional educational material (slides, videos, handouts, etc.) will be distributed or indicated during the lessons.
Chemistry and biochemistry propaedeutics	• R.C. Bauer - Introduction to chemistry (Piccin) • Masterton - Hurley Chemical Principles and Reactions (Piccin) • J. R. Amend, B. P. Mundy, M. T. Arnold - Chimica Generale, Organica e Biologica (Piccin) • Denniston - General and Organic Chemistry (McGraw-Hill) Any additional educational material (slides, videos, handouts, etc.) will be distributed or indicated during the lessons.

Course format

Subject	Textbooks
Applied physics	The teaching will primarily be conducted through in-person lectures with a blend of theory and practical exercises. In the event that teaching is delivered in a blended or remote mode, necessary adjustments may be introduced compared to what has been previously stated, in order to adhere to the planned program as outlined in the Syllabus.
Chemistry and biochemistry propaedeutics	

Attendance

Subject	Textbooks
Applied physics	Mandatory attendance.
Chemistry and biochemistry propaedeutics	

Course schedule

Subject	Textbooks
Applied physics	• Introduction (Chapter 1) • Mechanics (Chapter 1, 2) • Fluid mechanics (Chapter 3) • Thermodynamics (Chapter 5) • Electromagnetism (Chapter 7,9) • Waves and optics (Chapter 8,10)
Chemistry and biochemistry propaedeutics	• Atomic structure and chemical bonding (Chapter 1, 2, 3) • Chemical systematics and reactions (Chapter 4, 5) • Chemical reactions including stoichiometric principles (Chapter 6, 7, 8) • Organic Compounds (Chapter 9) • Test reactions (Chapter 10)