I year (1st semester) **A.Y. 2025-2026**	Scientific Field	**PHYSICS AND STATISTICS**	TUTOR	ECTS
	FIS/07	Applied Physics (Medicine)	Toschi Nicola	5
		Applied Physics (Medicine)	Conti Allegra	3
	FIS/07	Informatics	Duggento Andrea	1
TOSCHI N. **COORDINATOR**	FIS/07	Medical Statistics	Leonardo Emberti Gialloreti	3
			TOT	12

PROGRAM **MEDICAL PHYSICS** **MECHANICS**	Chapter 1: Introduction, Measurement, Estimating Chapter 2: Describing Motion: Kinematics in One Dimension Chapter 3: Kinematics in Two Dimensions; Vectors Chapter 4: Dynamics: Newton's Laws of Motion Chapter 5: Circular Motion; Gravitation Chapter 6: Work and Energy Chapter 7: Linear Momentum Chapter 8: Rotational Motion Chapter 9: Static Equilibrium; Elasticity and Fracture

TOPICS INTRODUCTION, MEASUREMENT, ESTIMATING	1.1: The Nature of Science 1.2: Physics and its Relation to Other Fields 1.3: Models, Theories, and Laws 1.4: Measurement and Uncertainty; Significant Figures 1.5: Units, Standards, and SI Units 1.6: Converting Units 1.7: Order of Magnitude: Rapid Estimating 1.8: Dimensions and Dimensional Analysis

TOPICS DESCRIBING MOTION: KINEMATICS IN ONE DIMENSION	2.1: References Frames and Displacement 2.2: Average Velocity 2.3: Instantaneous Velocity 2.4: Acceleration 2.5: Motion at Constant Acceleration 2.6: Solving Problems 2.7: Falling Objects 2.8: Graphical Analysis of Linear Motion

TOPICS KINEMATICS IN TWO DIMENSIONS; VECTORS	3.1: Vectors and Scalars 3.2: Addition of Vectors-Graphical Methods 3.3: Subtraction of Vectors and Multiplication of a Vector By a Scalar 3.4: Adding Vectors by Components

TOPICS DYNAMICS: NEWTON'S LAWS OF MOTION	4.1: Force 4.2: Newton's First Law of Motion 4.3: Mass 4.4: Newton's Second Law of Motion 4.5: Newton's Third Law of Motion 4.6: Weight-The Force of Gravity; and the Normal Force 4.7: Solving Problems with Newton's Laws: Free-Body Diagrams 4.8: Problems Involving Friction, Inclines 4.9: Problem Solving-A General Approach

TOPICS CIRCULAR MOTION; GRAVITATION	5.1: Kinematics of Uniform Circular Motion 5.2: Dynamics of Uniform Circular Motion 5.3: Highway Curves, Banked and Unbanked 5.4: Nonuniform Circular Motion 5.5: Centrifugation 5.6: Newton's Law of Universal Gravitation 5.7: Gravity Near the Earth's Surface; Geophysical Applications 5.10: Types of Forces in Nature

TOPICS WORK AND ENERGY	6.1: Work Done by a Constant Force 6.2: Work Done by a Varying Force 6.3: Kinetic Energy and the Work-Energy Principle 6.4: Potential Energy 6.5: Conservative and Nonconservative Forces 6.6: Mechanical Energy and its Conservation 6.7: Problem Solving Using Conservation of Mechanical Energy 6.8: Other Forms of Energy: Energy Transformations and the Law of Conservation of Energy 6.9: Energy Conservation with Dissipative Forces: Solving Problems 6.10:Power

TOPICS LINEAR MOMENTUM	7.1: Momentum and Its Relation to Force 7.2: Conservation of Momentum 7.3: Collisions and Impulse 7.4: Conservation of Energy and Momentum in Collisions 7.5: Elastic Collisions in One Dimension 7.6: Inelastic Collisions 7.7: Collisions in Two or Three Dimensions 7.8: Center of Mass (CM) 7.9: CM of the Human Body 7.10: Center of Mass and Translational Motion

TOPICS ROTATIONAL MOTION	8.1: Angular Quantities 8.2: Constant Angular Acceleration 8.4: Torque 8.5: Rotational Dynamics; Torque and Rotational Inertia 8.6: Solving Problems in Rotational Dynamics 8.7: Rotational Kinetic Energy 8.9: Vector Nature of Angular Quantities

TOPICS STATIC EQUILIBRIUM; ELASTICITY AND FRACTURE	9.1: The Conditions for Equilibrium 9.2: Solving Statics Problems 9.3: Applications to Muscles and Joints 9.4: Stability and Balance 9.5: Elasticity; Stress and Strain 9.6: Fracture

PROGRAM **MEDICAL PHYSICS ELECTRICITY AND MAGNETISM**	Chapter 16: Electric Charge and Electric Field Chapter 17: Electric Potential Chapter 18: Electric Currents Chapter 19: DC Circuits Chapter 20: Magnetism Chapter 21: Electromagnetic Induction and Faraday's Law

TOPICS ELECTRIC CHARGE AND ELECTRIC FIELD	16.1: Static Electricity; Electric Charge and its Conservation 16.2: Electric Charge in the Atom 16.3: Insulators and Conductors 16.4: Induced Charge; the Electroscope 16.5: Coulomb's Law 16.6: Solving Problems Involving Coulomb's Law and Vectors 16.7: The Electric Field 16.8: Field Lines 16.9: Electric Fields and Conductors 16.10: Gauss's Law 16.11: Electric Forces in Molecular Biology: DNA Structures and Replication

TOPICS ELECTRIC POTENTIAL	17.1: Electric Potential Energy and Potential Differences 17.2: Relation Between Electric Potential and Electric Field 17.3: Equipotential Lines 17.4: The Electron Volt, a Unit of Energy 17.5: Electric Potential Due to Point Charges 17.7: Capacitance 17.8: Dielectrics 17.9: Storage of Electric Energy 17.11: The Electrocardiogram (ECG or EKG)

TOPICS ELECTRIC CURRENTS	18.1: The Electric Battery 18.2: The Electric Current 18.3: Ohm's Law: Resistance and Resistors 18.4: Resistivity 18.5: Electric Power 18.8: Microscopic View of Electric Current 18.10: Electrical Conduction in the Human Nervous System

TOPICS DC CIRCUITS	19.1: EMF and Terminal Voltage 19.2: Resistors in Series and in Parallel 19.3: Kirchhoff's Rules 19.4: EMFs in Series and in Parallel; Charging a Battery 19.5: Circuits Containing Capacitors in Series and in Parallel 19.6: RC Circuits-Resistor and Capacitor in Series 19.7: Electric Hazards

TOPICS MAGNETISM	Chapter 20: Magnetism 20.1: Magnets and Magnetic Fields 20.2: Electric Current Produce Magnetic Fields 20.3: Force on an Electric Current in a Magnetic Field: Definition of B 20.4: Force on a Electric Charge Moving in a Magnetic Field 20.5: Magnetic Field Due to a Long Straight Wire 20.8: Ampere's Law 20.9: Torque on a Current Loop; Magnetic Moment 20.11: Mass Spectrometer

TOPICS ELECTROMAGNETIC INDUCTION AND FARADAY'S LAW	21.1: Induced EMF 21.2: Faraday's Law of Induction; Lenz's Law 21.3: EMF Induced in a Moving Conductor 21.4: Changing Magnetic Flux Produces an Electric Field 21.8: Applications of Induction: Sound Systems, Computer Memory, Seismograph, GFCI

PROGRAM **MEDICAL PHYSICS VIBRATIONS AND WAVES**	Chapter 11: Vibrations and Waves Chapter 12: Sound Chapter 22: Electromagnetic Waves Chapter 24: The Wave Nature of Light

TOPICS VIBRATIONS AND WAVES	11.7: Wave Motion 11.8: Types of Waves: Transverse and Longitudinal 11.9: Energy Transported by Waves 11.10: Intensity Related to Amplitude and Frequency 11.11: Reflection and Transmission of Waves 11.12: Interference; Principle of Superposition 11.13: Standing Waves; Resonance
TOPICS SOUND	12-1 Characteristics of Sound 12-2 Intensity of Sound: Decibels *12-3 The Ear and Its Response; Loudness 12-4 Sources of Sound: Vibrating Strings and Air Columns *12-5 Quality of Sound, and Noise; Superposition 12-6 Interference of Sound Waves; Beats 12-7 Doppler Effect *12-8 Shock Waves and the Sonic Boom * 12-9 Applications: Sonar, Ultrasound, and Medical Imaging
TOPICS ELECTROMAGNETIC WAVES	22.1: Changing Electric Fields Produce Magnetic Fields; Maxwell's Equations 22.2: Production of Electromagnetic Waves 22.3: Light as an Electromagnetic Wave and the Electromagnetic Spectrum 22.5: Energy in EM Waves
TOPICS THE WAVE NATURE OF LIGHT	24.4: The Visible Spectrum and Dispersion
PROGRAM **MEDICAL PHYSICS NUCLEAR PHYSICS AND RADIOACTIVITY**	Chapter 27: Early Quantum Theory and Models of the Atom Chapter 30: Nuclear Physics and Radioactivity Chapter 31: Nuclear Energy; Effects and Uses of Radiation

TOPICS EARLY QUANTUM THEORY AND MODELS OF THE ATOM	27.1 Discovery and Properties of the Electron 27.2: Planck's Quantum Hypothesis; Blackbody Radiation 27.10: Early Models of the Atom 27.11: Atomic Spectra: Key to the Structure of the Atom 27.12: The Bohr Model

TOPICS NUCLEAR PHYSICS AND RADIOACTIVITY	30.1: Structure and Properties of the Nucleus 30.2: Binding Energy and Nuclear Forces 30.3: Radioactivity 30.4: Alpha Decay 30.5: Beta Decay 30.6: Gamma Decay 30.7: Conservation of Nucleon Number and Other Conservation Laws 30.8: Half-Life and Rate of Decay 30.9: Calculations Involving Decay Rates and Half-life 30.10: Decay Series 30.11: Radioactive Dating 30.13: Detection of Radiation

TOPICS NUCLEAR ENERGY; EFFECTS AND USES OF RADIATION	31.1: Nuclear Reaction and the Transmutation of Elements 31.4: Passage of Radiation Through Matter; Radiation Damage 31.5: Measurement of Radiation-Dosimetry 31.6: Radiation Therapy 31.7: Tracers and Imaging in Medicine 31.8: Emission Tomography 31.9: Nuclear Magnetic Resonance (NMR) and Magnetic Resonance Imaging (MRI)

PROGRAM **MEDICAL PHYSICS THERMODYNAMICS**	Chapter 13: Temperature and Kinetic Theory Chapter 14: Heat Chapter 15: The Laws of Thermodynamics

TOPICS TEMPERATURE AND KINETIC THEORY	13.1: Atomic Theory of Matter 13.2: Temperature and Thermometers 13.3: Thermal Equilibrium and the Zeroth Law of Thermodynamics 13.4: Thermal Expansion 13.6: The Gas Laws and Absolute Temperature 13.7: The Ideal Gas Law 13.8: Problem Solving with the Ideal Gas Law 13.9: Ideal Gas Law in Terms of Molecules: Avogadro's Number 13.10: Kinetic Theory and the Molecular Interpretation of Temperature

TOPICS HEAT	14.1 Heat as Energy Transfer 14.2 Internal Energy 14.3: Specific Heat 14.4: Calorimetry 14.5: Latent Heat 14.6: Heat Transfer: Conduction 14.7: Heat Transfer: Convection 14.8: Heat Transfer: Radiation

TOPICS THE LAWS OF THERMODYNAMICS	15.1: The First Law of Thermodynamics 15.2: Thermodynamic Processes and the First Law 15.3: Human Metabolism and the First Law 15.4: Second Law of Thermodynamics-Introduction 15.7: Entropy and the Second Law of Thermodynamics

PROGRAM	Chapter 10: Fluids

MEDICAL PHYSICS **FLUIDS**	

TOPICS FLUIDS	10.1: Phases of Matter 10.2: Density and Specific Gravity 10.3: Pressure in Fluids 10.4: Atmospheric Pressure Gauge Pressure 10.5: Pascal's Principle 10.6: Measurement of Pressure; Gauges and the Barometer 10.7: Buoyancy and Archimedes' Principle 10.8: Fluids in Motion; Flow Rate and the Equation of Continuity 10.9: Bernoulli's Principle 10.10: Applications of Bernoulli's Principle: from Torricelli to Airplanes, Baseballs, and TIA 10.11: Viscosity 10.12: Flow in Tubes: Poiseuille's Equation, Blood Flow 10.13: Surface Tension and Capillarity 10.14: Pumps and the Heart

TEXTBOOKS	“PHYSICS: Principles with Applications” - Douglas C. Giancoli - Sixth edition, Pearson Education. Inc, ISBN 0-13-060620-0

EXAM METHOD	- You will be required to attend independent examinations for both the Physics and the Statistics courses. You will be able to take both the Physics and Statistics exams either a) during the same exam session or b) during separate exam sessions, as long as both exams are taken within the same academic year. - You will receive a single grade for the Integrated Course in Physics and Statistics, which will be calculated as a weighted average of the two grades obtained in Physics and Statistics. The weight will be the credit hours assigned to each course. - Final Physics and Statistics grade = (0.7 Physics grade) + (0.3 Statistics grade)

	PHYSICS COURSE: You will undergo a written assessment composed of multiple choice questions and problems. If your score is: - Below 15: exam failed - Between 15 (included) and 17 (included): attend compulsory oral examination or withdraw (exam failed) - 18 or more: keep this as your final grade or attend optional oral examination.

MEDICAL STATISTICS	**The statistics part of the syllabus consists of two parts: one part will be covered during the lectures; another part is to be studied in depth or studied from scratch in the textbook. Both parts are examination topics.** **The following syllabus will be covered during the lectures:** Introduction to Statistics. Descriptive statistics and inferential statistics. Quantitative and qualitative variables. Frequencies. Tables, diagrams and graphs. Statistical indices: measures of central tendency and dispersion. Central limit theorem. Standardizations of data. The normal (Gaussian) curve and its properties. Standard error and confidence intervals. Statistical inference: null and alternative hypothesis, the p-value, statistical association. Association and causality. Risk and Odds. Hypothesis testing and introduction to statistical tests. Errors in statistics. Differences between proportions and between means: observed values and expected values. Student's t-test and one-way ANOVA. Chi-square test. Linear correlation. Univariate and multivariate linear regression. Logistic regression. Survival curves. Effect size.

MEDICAL STATISTICS **Topics**	**The following topics should be explored in depth or studied from scratch in the indicated textbook, paying particular attention to 'Lingo' and 'Common Mistakes' (the chapter of the book where the subject is to be studied is indicated). It is recommended to follow the order indicated in this paragraph.** The Complexities of Probability (Chapter 2). From Sample to Population (Chapter 3). Confidence Intervals (Chapter 4). Types of Variables (Chapter 5). Outliers (Chapter 21). Graphing Variability (Chapter 6). The Lognormal Distribution and Geometric Mean (Chapter 9). Comparing Groups with P Values (Chapter 13). Interpreting a Result that Is (Or Is Not) Statistically Significant (Chapter 15). Multiple Comparisons (Chapter 17). Commonly Used Statistical Tests (Chapter 19). Correlation (Chapter 22). Simple Linear Regression (Chapter 23). Common Mistakes to Avoid When Interpreting Published Statistics (Chapter 25).

TEXTBOOKS	**REFERENCE TEXT** Harvey Motulsky. Essential Biostatistics: A Nonmathematical Approach. Oxford University Press, 2016. **FOR FURTHER READING** Harvey Motulsky. Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking. Fourth Edition. Oxford University Press, 2017

EXAM COMMISSION	The Coordinator, full Professors of the disciplines, Professors of similar disciplines, Specialists of the subject, compose the exam Commission of the Integrated Course.

Toschi Nicola, President
Duggento Andrea
Emberti Gialloreti Leonardo

CONTACTS

Toschi Nicola	toschi@med.uniroma2.it	0672596008
Duggento Andrea	Duggento@med.uniroma2.it	
Emberti Gialloreti Leonardo	Leonardo.emberti.gialloreti@uniroma2.it	

PREREQUISITES: Previous knowledge and competence in Basic Physics and Statistics.

The specific learning outcomes of the program are coherent with the general provisions of the Bologna Process and the specific provisions of EC Directive 2005/36/EC. They lie within the European Qualifications Framework (Dublin Descriptors) as follows:

1. **Knowledge and Understanding**

- Demonstrate a comprehensive theoretical knowledge of the main physical principles and laws concerning kinetics, dynamics, electricity and magnetism, vibration and waves, radiation and nuclear physics and fluids dynamics.
- Understand the important conceptual models used in the core subject areas of physics, demonstrate the ability to correctly draw logical conclusions from these models and use them to make accurate quantitative predictions in realistic situations.
- Apply these concepts to the medical setting and understand their relationships with the physiological mechanisms which govern the human body as well as their application in the construction of diagnostic equipment.
- Identify and recognize the physical principles which govern the function of the specific human organs; demostrate the importance of their regulation in order to maintain equilibrium.
- Study the main statistical terms and notions and understand their application.

2. **Applying Knowledge and Understanding**

- Apply the principles of physics to selected problems and to a variable range of situations.
- Bring into play the statistical concepts in the analysis of clinical data and and their application in the conduction of clinical studies.
- Use the tools, methodologies, language and conventions of physics to test and communicate ideas and explanations.
- Learn how to conduct scientific experiments for the purpose of solving a scientific problem and to record and analyze the results

3. **Making Judgements**

- Recognize the importance of an in-depth knowledge of the topics consistent with a proper medical education.
- Identify the fundamental role of a proper theoretical knowledge of the subject in the clinical practice.

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4. **Communication Skills**

- Present the topics orally in a organized and consistent manner.
- Utilize a proper scientific language coherent with the topic of discussion.

5. **Learning Skills**

- Identify possible use of skills acquired during the course in the future career.
- Assess the importance of the acquired knowledge in the overall medical education process.