

Degree in Medicine and Surgery

Integrated Course: PHYSICS AND STATISTICS

Teaching: **Applied Physics**

SSD: **FIS/07**

CFU: **5**

Professor's name: **Iole Indovina** e-mail: **iole.indovina@unicamillus.org**

Teaching: **Information Technology**

SSD: **INF/01**

CFU: **4**

Professor's name: **Andrea Dimitri** e-mail: **andrea.dimitri@unicamillus.org**

Teaching: **Medical Statistics**

SSD: **MED/01**

CFU: **3**

Professor's name: **Francesco Vairo** e-mail: **francesco.vairo@unicamillus.org**

PREREQUISITES

The course does not include preliminary qualifications, however knowledge and competence in Basic Mathematics, Physics, Informatics and Statistics at High School level are expected.

LEARNING OBJECTIVES

Aim of the integrated course of Physics and Statistics (Applied Physics, Medical Statistics and Informatics) is to provide students with knowledge on the fundamentals of applied physics, Statistics and Informatics necessary for their future activity. In particular, the comprehension of physical principles at the base of medical physics and of functioning of medical instrumentation will be addressed.

At the end of the course, the students will know the fundamental concepts of application of the Scientific Method to the study of biomedical phenomena (choice and measure of parameters, evaluation of errors), they will be able to describe physical phenomena of complex systems using suitable mathematical tools, they will know the scientific basis of medical procedures and principles of functioning of the equipment commonly used for diagnostics and therapeutics.

The student should be able to understand the tools and computer concepts that will be useful for their future profession in the medical field and understand the importance of medical statistics in the research methodology in the medical field; - read a basic biomedical scientific article, understanding its structure and critically evaluating methods and results; handle a simple database, with particular reference to clinical medicine; make a descriptive and inferential analysis.

LEARNING OUTCOMES

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 :

- Understand the experimental method and learn the use and transformation of measure units.
- Know and understand the proper terminology of physics.
- Know and understand the main physical principles and laws concerning kinetics, dynamics, electricity and magnetism, vibration and waves, radiation, nuclear physics and fluids.
- Apply these concepts to biological and physiological phenomena in living organisms.
- Identify and recognize the physical principles which govern the function of the specific human organs.
- carry out a descriptive analysis of a simple database;
- evaluate the association between variables;
- know the basic principles of correlation and linear regression analysis;
- know and apply frequency and effect measurements;
- explain how statistical inference is applied to biomedical research;
- demonstrate an understanding of probability and its application;
- demonstrate ability to manage data and to draw and present quantitative results effectively, using appropriate tables, figures and summaries
- describe the nature of the sampling variation and the role of the statistical methods in quantifying it, and be able to calculate the confidence limits and evaluate the hypotheses;
- select and use appropriate statistical methods in the analysis of simple data sets;
- interpret and evaluate the results of statistical analyses within a scientific publication;
- present and discuss the results of statistical analyses in a clear, concise and comprehensible way,
- describe the general principles of the calculation of the sample size and power.

2. Applying Knowledge and Understanding

- Apply the principles of physics, informatics and statistics to selected problems and to a variable range of situations.
- Use the tools, methodologies, language and conventions of physics, informatics and statistics to test and communicate ideas and explanations.

3. Communication Skills

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

4. 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 topic in the clinical practice.

PHYSICS SYLLABUS

Mechanics

Chapter 1: Introduction, Measurement, Estimating

- 1.4: Measurement and Uncertainty; Significant Figures
- 1.5: Units, Standards, and SI Units
- 1.6: Converting Units
- 1.8: Dimensions and Dimensional Analysis

Chapter 2: Describing Motion: Kinematics in One Dimension

- 2.1: Reference Frames and Displacement
- 2.2: Average Velocity
- 2.3: Instantaneous Velocity
- 2.4: Acceleration
- 2.5: Motion at Constant Acceleration

Chapter 3: 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

Chapter 4: 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

Chapter 5: Circular Motion; Gravitation

- 5.1: Kinematics of Uniform Circular Motion
- 5.2: Dynamics of Uniform Circular Motion
- 5.6: Newton's Law of Universal Gravitation

Chapter 6: Work and Energy

- 6.1: Work Done by a Constant 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
- 6.10: Power

Chapter 7: Linear Momentum

- 7.1: Momentum and Its Relation to Force
- 7.2: Conservation of Momentum
- 7.8: Center of Mass (CM)
- 7.10: Center of Mass and Translational Motion

Chapter 8: 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

Chapter 9: 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

Electricity and Magnetism

Chapter 16: 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

Chapter **17**: 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

Chapter **18**: 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

Chapter **19**: 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

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 an Electric Charge Moving in a Magnetic Field
- 20.5: Magnetic Field Due to a Long Straight Wire
- 20.8: Ampere's Law

Chapter **21**: 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

Vibrations and Waves

Chapter 11: 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

Chapter 12: Sound

- 12-1 Characteristics of Sound
- 12-2 Intensity of Sound: Decibels
- 12-4 Sources of Sound: Vibrating Strings and Air Columns
- 12-6 Interference of Sound Waves; Beats
- 12-7 Doppler Effect

Chapter 22: 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

Chapter 24: The Wave Nature of Light

- 24.4: The Visible Spectrum and Dispersion

Chapter 25: Optical Instruments

- 25-11: X-Rays and X-Ray Diffraction**
- 25-12: X-Ray Imaging and Computed Tomography (CT Scan)**

Nuclear Physics and Radioactivity

Chapter 27: Early Quantum Theory and Models of the Atom

- 27.10: Early Models of the Atom
- 27.12: The Bohr Model

Chapter 30: 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

Chapter **31**: Nuclear Energy; Effects and Uses of Radiation

- 31.1: Nuclear Reaction and the Transmutation of Elements
- 31.5: Measurement of Radiation-Dosimetry
- 31.9: Nuclear Magnetic Resonance (NMR) and Magnetic Resonance Imaging (MRI)

Thermodynamics

Chapter **13**: 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

Chapter **14**: 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

Chapter **15**: The Laws of Thermodynamics

- 15.1: The First Law of Thermodynamics
- 15.2: Thermodynamic Processes and the First Law
- 15.4: Second Law of Thermodynamics-Introduction

Fluids

Chapter 10: 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

INFORMATICS SYLLABUS

- 1) Introduction to health information systems. The Italian health information system. Health standards for data acquisition, storing and visualization. The electronic medical record.
- 2) Privacy and security in the management of healthcare data.
- 3) Introduction to databases. The E-R schema. RDBMS: tables, records, fields, queries using the SQL language. Public health databases:
 - PubMed, Medline, Medline plus.
 - Cochrane Library
- 4) Data mining in Healthcare. How to read the output of a statistical package. The use of R.
- 5) Digital devices, sensors and mobile app for precise medicine. Supporting systems for the physicians.

STATISTICS SYLLABUS

- Introduction to biomedical statistics
- Types of data, evaluation and presentation of data
- Probability: assessment and role of probability
- The binomial distribution
- Normal distribution
- Principles of statistical inference
- Inference from a sample mean
- Comparison of two averages
- Inference from a sample proportion
- Comparison between two proportions
- Association between two categorical variables
- Effect measurement in 2 x 2 tables
- Combined analysis for associated binary data

- Correlation
- Linear regression
- Non-parametric methods
- Introduction to the calculation of the sample size
- Cohort studies
- Introduction to survival analysis
- Case-control studies
- Probability
- Introduction to multivariate regression
- Introduction to logistic regression
- Introduction to the Poisson and Cox regression
- Strategies of analysis

COURSE STRUCTURE

The teaching consists of hours of frontal teaching, divided into 2 or 4 hour lessons based on the academic calendar. The frontal teaching includes hours of theoretical lessons and hours of exercises on the topics covered. Attendance is mandatory for at least 75% of the hours, summed over all the teachings of the integrated course. Before the course, there will be preliminary lessons necessary to the recovery of the mathematical concepts and skills that are necessary prerequisites for a successful development of the Integrated Course.

COURSE GRADE DETERMINATION

The exam of the Integrated Course of PHYSICS, STATISTICS and INFORMATICS is comprised of an evaluation test of PHYSICS, an evaluation test of STATISTICS, and one of INFORMATICS whose marks are an integral part of the Integrated Course exam evaluation.

During the oral part of the exam communication skills, language skills and learning skill of the student are considered based on Dublin Descriptors.

The student can take the PHYSICS, STATISTICS or INFORMATICS tests in a single session or in different sessions of the academic year according to the modalities listed below.

PHYSICS ASSESSMENT TEST: The Physics test consists of mandatory written and oral tests. The written test is aimed at evaluating both the theoretical knowledge and the student's ability to solve problems, the oral exam is aimed at further evaluating his reasoning and communication skills on the topics of study. The result of the written test is valid for one academic year. The written test consists of 15 multiple choice questions. Each correct answer gets a score of 2/30, while there is no penalty for wrong answers. Only students who have obtained at least 12/30 in the written test are admitted to the oral test.

The exam grade is established according to the following criteria:

Exam failed: important deficiencies and / or inaccuracies in knowledge and understanding of the topics; limited capacity for analysis and synthesis, frequent generalizations.

18-20: Just sufficient knowledge and understanding of the subjects with possible imperfections; ability to analyze synthesis and sufficient judgment autonomy.

21-23: Modest knowledge and understanding of topics; Correct analysis and synthesis skills with coherent logical argumentation.

24-26: Good knowledge and understanding of the topics; good analytical and synthesis skills with rigorously expressed arguments.

27-29: Complete knowledge and understanding of the subjects; remarkable analytical skills, synthesis. Good independence of judgment.

30-30L: Excellent level of knowledge and understanding of the topics. Considerable analytical and synthesis skills and autonomy of judgment. Arguments expressed in an original way.

INFORMATION TECHNOLOGY ASSESSMENT TEST: The survey associated consists of 15 questions with multiple choice answers. For each question there is also a free space when the student can motivate his answers. Each correct answer will receive a score from 1 to 2, considering the quality of it. To access the oral exam the student must have totaled at least 18 points.

STATISTICS ASSESSMENT TEST: The written test will consist of 20 questions with multiple choice answers and two exercises. For each correct answer a point will be assigned. A maximum of 5 points will be awarded for each exercise. The final score of the written test will be given by the sum of the partial scores assigned to each question correctly answered and the scores assigned to the exercises. To access the oral exam the student must have a minimum of 18 points.

OPTIONAL ACTIVITIES

In addition to the teaching activity, the student will be given the opportunity to participate in seminars, research internships, department internships and monographic courses. The topics of the activities are not subject to examination. Acquisition of the hours allocated occurs only with a mandatory frequency of 100%.

READING MATERIALS

PHYSICS : Douglas C. Giancoli “PHYSICS: Principles with Applications” Seventh edition or subsequent, Pearson Education. Inc

INFORMATICS :

Handouts by the teacher.

Kathleen Mastrian, Dee McGonigle - Informatics for Health Professionals. Jones & Bartlett Learning; 1 edition (April 25, 2016)

Joseph Tan - E-Health Care Information Systems: An Introduction for Students and Professionals. Jossey-Bass Inc Pub; 1 edizione (May 1, 2012)

STATISTICS :

Lesson slides

Essential medical statistics (Kirkwood, Sterne)

The indicated textbook is just a reference. Students are allowed to adopt the book/books of their choice. Additional material will be provided by the instructor.