Degree in Medicine and Surgery

Course: Physics and Statistics 12 CFU
Coordinator: Prof. Alessandra Filabozzi

Subject: **Applied Physics**
SSD: **FIS/07**
CFU: **5**
Professor: **Alessandra Filabozzi** e-mail: **alessandra.filabozzi@unicamillus.org**

Subject: **Information Technology**
SSD: **INF/01**
CFU: **4**
Professor: **Andrea Dimitri** e-mail: **andrea.dimitri@unicamillus.org**

Subject: **Medical Statistics**
SSD: **MED/01**
CFU: **3**
Professor: **Francesco Vairo** e-mail: **francesco.vairo@unicamillus.org**

PREREQUISITES

Knowledge and skills in mathematics, statistics and basic computer science at secondary school level, including arithmetic, algebra, Euclidean geometry, trigonometry and elements of differential and integral calculus. However, the teaching does not include preliminary qualifications.

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 Intormatics 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: References 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 a mandatory written test and an optional oral exam. 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 improving the evaluation obtained with the written test. The written test consists of a series of multiple choice questions. The maximum score, equal to 30 cum laude, is foreseen for those who answer all the questions correctly; the minimum score, equal to 18 out of 30, is foreseen for those who correctly answer 18/30 of the questions, taking into account the different weight attributed to them. The questions may have a different weight based on the complexity of the question and on the particular knowledge that is verified. There is no penalty for wrong answers. Only students wishing to improve the assessment obtained with the written test are admitted to the oral exam.

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 al 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 ed (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.