UNICAMILLUS

Degree in Medicine and Surgery
Course: Physics and Statistics 12 CFU
SSD: FIS/07; INF/01; MED/01
Coordinator: Domenico Rocco

Subject: **Applied Physics**
SSD: **FIS/07**
CFU: **5**
Professor: **Gian Marco Contessa** e-mail: gianmarcocontessa@gmail.com
Professor: **Alessia Mattacchioni** e-mail: sally.mattacchioni@gmail.com
Professor: **Marco D'Arienzo** e-mail: marco.darienzo@asrlroma6.it

Subject: **Information Technology**
SSD: **INF/01**
CFU: **3**
Professor: **Domenico Rocco** e-mail: **domenico.rocco@unicamillus.org**

Subject: **Medical Statistics**
SSD: **MED/01**
CFU: **4**
Professor: **Monica Sane Schepisi (2 CFU)** e-mail: **saneschepisi@hotmail.com**
Professor: **Luca Paolo Weltert (2 CFU)** e-mail: **luca.weltert@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 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.

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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.

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5. Learning skills

At the end of the integrated teaching, the student will acquire skills useful to deepen and expand their knowledge in the field of the course, also through the consultation of scientic literature, databases, specialized websites.

PHYSICS SYLLABUS
Prof. Gian Marco Contessa

MECHANICS

Introduction, Measurement, Estimating
Measurement and Uncertainty; Significant Figures
Units, Standards, and SI Units
Converting Units
Dimensions and Dimensional Analysis
Vectors and Scalars

Vectors
Addition of Vectors-Graphical Methods
Subtraction of Vectors and Multiplication of a Vector by a Scalar
Adding Vectors by Components
Scalar and Vector Products

Describing Motion: Kinematics
References Frames and Displacement
Average Velocity
Instantaneous Velocity
Acceleration
Motion at Constant Acceleration
Kinematics of Uniform Circular Motion
Nonuniform Circular Motion

Dynamics:
Newton’s Laws of Motion
Force
Newton’s First Law of Motion
Mass
Newton’s Second Law of Motion
Newton’s Third Law of Motion
Weight-The Force of Gravity;
The Normal Force
Friction
Elasticity and Hooke’s Law
Circular Motion; Gravitation
Dynamics of Uniform Circular Motion
Newton's Law of Universal Gravitation
Types of Forces in Nature

Work and Energy
Work Done by a Constant Force
Kinetic Energy and the Work-Energy Principle
Potential Energy (gravitational potential energy, potential energy of elastic spring)
Conservative and Nonconservative Forces
Mechanical Energy and its Conservation
Problem Solving Using Conservation of Mechanical Energy
Other Forms of Energy: Energy Transformations and the Law of Conservation of Energy
Power

Linear Momentum
Momentum and its Relation to Force
Conservation of Momentum
Center of Mass
Center of Mass and Translational Motion

Rotational Motion
Angular Quantities
Torque

Static Equilibrium
The Conditions for Equilibrium
Applications to Muscles and Joints
Stability and Balance
Elasticity
Stress and Strain
Fracture

Fluids
Phases of Matter
Density
Pressure in Fluids
Atmospheric Pressure; Gauge Pressure
Pascal's Principle
Buoyancy and Archimedes' Principle
Fluids in Motion;
Flow Rate and the Equation of Continuity
Bernoulli's Principle
Applications of Bernoulli's Principle: stenosis, aneurism and TIA
Viscosity
Flow in Tubes: Poiseuille's Equation, High blood pressure
Pumps, and the Heart

THERMODYNAMICS
Temperature
Atomic Theory of Matter
Temperature and Thermometers
Thermal Equilibrium
Thermal Expansion

Heat
Heat as Energy Transfer
Internal Energy
Specific Heat
Calorimetry
Heat Transfer: Conduction
Heat Transfer: Convection
Heat Transfer: Radiation

The Laws of Thermodynamics
The First Law of Thermodynamics
Human Metabolism and the First Law
Second Law of Thermodynamics-Introduction
Entropy and the Second Law of Thermodynamics
Order to Disorder

PHYSICS SYLLABUS
Prof. Alessia Mattacchioni

Electricity and Magnetism

Electric Charge and Electric Field
Static Electricity; Electric Charge and its Conservation
Electric Charge in the Atom
Insulators and Conductors
Induced Charge; the Electroscope
Coulomb's Law
The Electric Field
Field Lines

Electric Potential
Electric Potential Energy and Potential Differences
Relation Between Electric Potential and Electric Field
Equipotential Lines
The Electron Volt, a Unit of Energy
Electric Potential Due to Point Charges
Capacitance
Dielectrics
Storage of Electric Energy
Monitors: CRTs, Flat Screens 490
Electrocardiogram (ECG or EKG)

Electric Currents
The Electric Battery
The Electric Current
Ohm's Law: Resistance and Resistors
Resistivity

Electric Power
Microscopic View of Electric Current
Superconductivity
Electrical Conduction in the Human Nervous System

DC Circuits
EMF and Terminal Voltage
Resistors in Series and in Parallel
Kirchhoff's Rules
EMFs in Series and in Parallel; Charging a Battery
Circuits Containing Capacitors in Series and in Parallel
RC Circuits-Resistor and Capacitor in Series

Magnetism
Magnets and Magnetic Fields
Electric Current Produce Magnetic Fields
Force on an Electric Current in a Magnetic Field: Definition of B
Force on an Electric Charge Moving in a Magnetic Field
Magnetic Field Due to a Long Straight Wire
Ampere's Law

Electromagnetic Induction and Faraday's Law
Induced EMF
Faraday's Law of Induction; Lenz's Law
EMF Induced in a Moving Conductor
Changing Magnetic Flux Produces an Electric Field

Vibrations and Waves
Vibrations and Waves
Wave Motion
Types of Waves: Transverse and Longitudinal
Energy Transported by Waves
Reflection and Transmission of waves
Interference; Principle of Superposition
Standing Waves; Resonance

Sound
Characteristics of Sound
Intensity of Sound: Decibels
The Ear and Its Response; Loudness
Sources of Sound: Vibrating Strings and Air Columns
Quality of Sound, and Noise; Superposition
Interference of Sound Waves; Beats
Doppler Effect
Applications: Ultrasound and Medical Imaging

Electromagnetic Waves
Changing Electric Fields Produce Magnetic Fields; Maxwell's Equations
Production of Electromagnetic Waves
Light as an Electromagnetic Wave and the Electromagnetic Spectrum

Energy in EM Waves

The Wave Nature of Light
The Visible Spectrum and Dispersion

Optical Instruments
The Human Eye; Corrective Lenses
Resolution of the Human Eye and Useful Magnification

PHYSICS SYLLABUS
Prof. Marco D'Arienzo

Radiation in Healthcare
Electromagnetic radiation
ionizing and non-ionizing radiation
Medical uses for radiation (diagnostics and in therapy)

Ionizing radiation in medicine
X-Ray Medical Imaging
Physical principles and technical aspects of diagnostics x-ray devices
Computed Tomography (CT)
Single Photon Emitting Tomography (SPECT)
C-arm systems and other x-ray equipment

Non-ionizing radiation:
Magnetic Resonance Imaging (MRI)

Radiation protection
Interaction of radiation with cells and tissues
Radiobiology

INFORMATION TECHNOLOGY SYLLABUS

1) Binary system and information encoding, input and output, boolean operators.
2) Computer architecture, CPU, memory
3) Software: operating systems, application software
4) Word processing (Microsoft Word) for bibliography management
5) Spreadsheets (Microsoft excel): basic functions
6) Computer networks, internet, e-mail, World Wide Web
7) Databases and search engines. Health databases
8) Introduction to health information systems. The national health information system. Health standards related to data acquisition, storage and visualization. The electronic medical records.
9) Fundamentals of Cybersecurity and Privacy in Health Data Management.
10) Personalized medicine, mobile e-health. Health decision support systems.

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MEDICAL STATISTICS SYLLABUS

- Introduction to Biomedical Statistics
  - Data types, evaluation and presentation
  - Probability: assessment and role of probability
  - The binomial distribution
  - The normal distribution
  - Principles of statistical inference
  - Inference from a sample average
  - Comparison of two averages
  - Inference from a sample proportion
  - Comparison between two proportions
  - Association between two categorical variables
  - Effect measurement in Tables 2 x 2
  - Matched analysis for associated binary data
  - Correlation
  - Linear regression
  - Non-parametric methods
  - Introduction to the calculation of sample size
  - Cohort studies
  - Introduction to Survival Analysis
  - Case-control studies
  - Probability
  - Introduction to Multivariate Regression
  - Introduction to Logistic Regression
  - Introduction to the regression of Poisson and Cox
  - Analysis strategies

COURSE STRUCTURE

The teaching consists of 10 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.

ASSESSMENT TEST: The test consists in a written exam (multiple choice questionnaire). The questions may have a different weight based on the complexity of the question and on the particular knowledge that is verified.

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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

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

G.M. Contessa, G.A. Marzo. Fisica Applicata alle Scienze Mediche. Casa Editrice Ambrosiana, 2019

The indicated textbooks are just for reference. Students are allowed to adopt the book/books of their choice. Additional material will be provided by the professor as lesson slides

INFORMATION TECHNOLOGY
Joos, D. Wolf, R. Nelson, "Introduction to Computers for Healthcare Professionals" seventh edition, 2019, Jones & Bartlett Learning, ISBN 978-1284194708

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 (1 maggio 2012)

MEDICAL STATISTICS
Lectures' slides are the main point of reference for studying.
Essential Medical Statistics (Kirkwood, Sterne)

The indicated textbooks are just for reference. Students are allowed to adopt the book/books of their choice. Additional material will be provided by the professor as lesson slides