

Degree Medicine and Surgery

Integrated Teaching: **Physics and Statistics**

SSD: FIS06/A; INF01/A; MED24/A

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CFU: 12

Module: **Applied Physics**

SSD: FIS06/A

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CFU: 5

Module: **Informatics**

SSD: INF01/A

Professor: Prof. [Domenico Rocco](#) (1 CFU)

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CFU: 3

Teaching module: **Medical Statistics**

SSD: MED24/A

Professor: Prof. Anne Rutjes (1 CFU)

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Professor: Prof. [Francesco Bartolozzi](#) (1 CFU)

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Professor: Prof. [Fabrizio Carinci](#) (2 CFU)

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CFU: 4

PREREQUISITES

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

LEARNING OBJECTIVES

The aim of the integrated Physics and Statistics course (Applied Physics, Medical Statistics and Computer Science) is to provide students with the knowledge of the fundamentals of applied physics, computer science and statistics necessary for their future work. In particular, an understanding of the physical principles underlying medical physics and the functioning of medical instrumentation will be addressed.

At the end of the module, students will know the fundamental concepts of the application of the



Scientific Method to the study of biomedical phenomena (choice and measurement of parameters, evaluation of errors), they will be able to describe the physical phenomena of complex systems using appropriate mathematical tools, they will know the scientific basis of medical procedures and the operating principles of equipment commonly used for diagnostics and therapy.

Students should understand the computer tools and concepts that will be useful to them in their future profession in the medical field. It is an essential objective of the Medical Statistics course to learn the knowledge of the essential elements of medical statistics, which include: parameters for descriptive analysis (mean, median, fashion and frequency measures of the distribution of categorical variables), parameters for the analysis of variability (variance, standard deviation and confidence intervals) and elements of inferential statistics (use and interpretation of the most common statistical tests), and regression techniques. Students must be able to: understand the importance of medical statistics in medical research methodology; read a basic biomedical scientific article, understanding its structure and critically evaluating its methods and results; handle a simple database, with particular reference to clinical medicine; carry out descriptive and inferential analysis.

LEARNING OUTCOMES

The expected learning outcomes are consistent with the general provisions of the Bologna Process and the specific provisions of Directive 2005/36 / EC. They are found within the European Qualifications Framework (Dublin descriptors) as follows:

Knowledge and understanding

- To have understood the experimental method and to have acquired rigour in the use and transformations of units of measurement;
- To know and correctly understand the terminology of physics, statistics and computer science. - Know the fundamental principles and laws of physics concerning kinematics, dynamics, electricity and magnetism, vibrations and waves, radiation, nuclear physics and fluids. - Apply these concepts to biological and physiological phenomena in living organisms. - Identify and recognise the physical principles governing the function of specific human organs. - Know the basics of an information system in a healthcare facility. Furthermore, he/she must know how a database is organised and must know some basics of database query languages. He/she must know the security and privacy issues associated with the management of sensitive and non sensitive data such as health data. They must know the problems associated with reading data from electronic instruments, units of measurement, standards, errors.
- Perform a descriptive analysis of a simple database; know and apply frequency and effect measures;
- Demonstrate an understanding of probability and its application;
- Demonstrate ability to handle data and to draw and present quantitative results effectively, using appropriate tables, figures and summaries;
- Evaluate the association between variables;
- Describe the nature of sampling variation and the role of statistical methods in quantifying it, and be able to calculate confidence limits and evaluate assumptions;
- Select and use appropriate statistical methods in the analysis of simple data sets; -



Understand the concepts of confounding and effect modification;

- Select and use appropriate statistical methods in the analysis of simple data sets; - Know the basic principles of correlation and linear regression analysis;
- Know introductory elements of survival analysis, multiple linear regression, logistic regression, Cox and Poisson regression analyses;
- Explain how statistical inference is applied biomedical research;
- Describe the general principles of power sample size calculation;
- 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 understandable manner.

EXPECTED LEARNING OUTCOMES

Applying knowledge and understanding

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

Communication skills

- Explain arguments in an organized and coherent manner.
- Use scientific language appropriately and in accordance with the topic of discussion.

Making judgements

- Recognise the importance of in-depth knowledge of topics in accordance with appropriate medical education.
- Identify the fundamental role of correct theoretical knowledge of the subject in clinical practice.

SYLLABUS

APPLIED PHYSICS

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



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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



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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

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



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

Electric Charge and Electric Field

Static Electricity
Insulators and Conductors
Induced Charge
Coulomb's Law
The Electric Field

Electric Potential

Electric Potential Energy
Electric Potential Due to Point Charges
Capacitance Dielectrics

Electric Currents

The Electric Current
Ohm's Law: Resistance and Resistors
Electric Power
Microscopic View of Electric Current
Electrical Conduction in the Human Nervous System

DC Circuits

EMF and Terminal Voltage
Resistors in Series and in Parallel
Kirchhoff's Rules
RC Circuits

Magnetism

Magnets and Magnetic Fields
Electric Current and Magnetic Fields
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

Wave Motion
Types of Waves: Transverse and
Longitudinal Reflection and Transmission of



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waves Interference; Principle of
Superposition Standing Waves; Resonance
Characteristics of Sound

The Ear and Its Response
Doppler Effect
Applications: Ultrasound and Medical Imaging

Electromagnetic Waves

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

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

- Binary system and information codification, input and output, boolean operators. Computer architecture, CPU, memories:
- Software: operating systems, application software:
- Word processor (Microsoft Word), including bibliography, citations and



references: Spreadsheet (Microsoft excel):

- Computer networks, Internet, e-mail. World Wide Web:
- Databases, Academic databases and search engines. Public health databases
- Introduction to health information systems. The Italian health information system. Health standards for data acquisition, storing and visualization. The electronic medical record.
- Information security and Privacy in the management of healthcare data.
- Digital devices, sensors and mobile app for precise medicine. Supporting systems for the physicians.
- Analog to digital conversion

MEDICAL STATISTICS

- Introduction to biomedical statistics
- Data types, evaluation and presentation
- Probability: evaluation and the role of probability
- Normal distribution, sampling techniques
- Principles of statistical inference
- Inference from a sample mean, comparison of two means; inference from a sample proportion, comparison of two proportions
- The hypothesis testing system, the chi-square test
- Correlation
- Linear regression
- Non-parametric methods
- Introduction to sample size calculation
- Evaluation of diagnostic tests, reproducibility of measurements
- Cohort studies
- Introduction to survival analysis
- Case-control studies
- Probability
- Introduction to multivariate regression
- Introduction to logistic regression
- Introduction to Poisson and Cox regression
- Analysis strategies

COURSE GRADE DETERMINATION

The examination of the Integrated Teaching of PHYSICS, STATISTICS and INFORMATICS consists of a comprehensive assessment test.



During the written test, the Board of Examiners will assess the student's ability to apply the knowledge and will ensure that the skills are adequate to achieve the objectives. The following will also be assessed: autonomy of judgment, communication skills and learning ability according to the Dublin descriptors.

EVALUATION TEST: Student preparedness will be assessed through a written exam. Some questions may carry different weights (scores) based on their complexity. Questions may be multiple-choice, open-ended, or require problem-solving or exercises. The evaluation for each course will be graded on a scale of thirty. The calculated grade for the integrated course will be the result of a weighted average that takes into account the credit value of each course within the integrated program.

The examination will be assessed overall according to the following criteria:

Not sufficient: significant deficiencies and/or inaccuracies in knowledge and understanding of the topics; limited ability to analyze and synthesize, frequent generalisations.

18-20: barely sufficient knowledge and understanding of the topics with possible imperfections; sufficient ability to analyze, synthesize and make independent judgements.

21-23: routine knowledge and understanding of the topics; correct analysis and synthesis skills with coherent logical argumentation.

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

27-29: comprehensive knowledge and understanding of the topics; considerable ability to analyze, synthesize. Good autonomy of judgment.

30-30L: very good knowledge and understanding of topics. Remarkable ability to analyze and synthesize and independent judgment. Arguments expressed in an original manner

OPTIONAL ACTIVITIES

In addition to the teaching activity, the student will be given the opportunity to deepen the topics covered by attending seminars and by suggesting additional readings of articles and book chapters. The topics of the A.D.E. do not constitute examination subjects. The acquisition of the hours allocated to the A.D.E. only takes place with a compulsory attendance of 100%.



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READING MATERIALS

APPLIED PHYSICS:

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

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.

INFORMATION TECHNOLOGY: Lesson slides

Hardy, Lynda R, “Health informatics. An interprofessional approach”;

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)

The indicated textbooks are just a reference.

MEDICAL 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.