UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# COURSE SYLLABUS

## Statistics

**2627-1-F7402Q004**

### Aims

**Knowledge and understanding:**

- To understand the fundamental concepts of probability and statistics.
- To recognize when a phenomenon can be modeled as random.
- To understand the behavior of the averages of a large number of independent and identically distributed random variables.

**Applying knowledge and understanding:**

- To apply concepts of probability and statistics to real-world situations characterized by randomness.
- To estimate the probability of events in concrete contexts.
- To select the most appropriate probabilistic model among several alternatives for describing a real-world problem.
- To estimate unknown parameters based on a random sample.
- To apply statistical tests to assess hypotheses about distribution parameters and to correctly interpret the results.

**Making judgements:**

- To critically assess the plausibility of statistical hypotheses in relation to the context in which the data were collected.
- To discuss the theoretical and practical implications of the adopted probabilistic models.

**Communication skills:**

- To clearly and rigorously communicate the analyses performed, the statistical methods employed, and the conclusions drawn.

**Learning skills:**

- Develop the ability to independently study probabilistic and statistical issues, also in relation to data collected personally or from external sources.
- Develop a critical and reflective approach to the interpretation of random phenomena.

## Contents

It is a first level course on the basic tools of descriptive and inferential statistics:

- descriptive statistics
- probability/random models
- inferential statistics: punctual and interval estimates, hypothesis testing

## Detailed program

The program is the same for both attending and not attending students.

Descriptive Statistics

Data vectors, mean,variance, standard deviation. Histograms. Median, quartiles, quantiles, Boxplot. Covariance and correlation, scatterplot.

Probability

Probability of events; independence of events. Discrete random variables, density, distribution function, mean and variance of discrete random variables. Examples: discrete uniform, binomial, geometric, Poisson. Continuous random variables, density, distribution function, mean, variance. Examples: continuous uniform, exponential, Gaussian. Law of largenumbers. Central limit theorem (use of the tables of the standard normal).

Inferential Statistics

Samples, estimators, unbiased estimators. Estimator of the mean. Unbiased estimator of the variance.

Confidence intervals for the mean (with known or unknown variance).

Test of hypothesis. First and second type error. Level of a test, P-value.

Test on a mean (monolateral and two-sided with known or unknown variance). Test on two averages. Chi-squared test of adaptation and of independence.

Linear regression.

## Prerequisites

Set theory; real functions; calculus (minima and maxima of functions, series and integration of real functions).

## Teaching form

- 10 2-hours lessons and one 1-hour lessons, Delivered Didactics in presence (DD total 21h);
- 9 1-hour lesson, Delivered Didactics online (asynchronous DD, totale 9h);
- 5 1-hour lessons online Interactive Teaching (asynchronous IT, total 5h);
- 1 12-hours exercise activity, online Interactive Teaching (asynchronous IT).

## Textbook and teaching resource

**Textbooks:**

- Calcolo delle probabilità e Statistica, di Marco Bramanti, Esculapio Editore.
- Esercizi di probabilità e statistica, di Bertacchi, Bramanti e Guerra, Esculapio Editore

**Other material on elearning.unimib.it:**

- Lecture slides
- Video of some lessons
- Video of exercises
- Multiple answer quizzes
- Interactive exercises on the platform wims.matapp,unimib.it

## Semester

Second semester (March-June)

## Assessment method

The assessment is based on online work and a written exam, plus an oral examination.

- The written exam contains multiple choice questions (of the kind present in the e-learning platform), open-ended theoretical questions (on definitions or theoretical results highlighted in the transparency of the lessons) and exercises (of the type present on the wims platform, some of them must be transcripts on paper). The written exam lasts from a minimum of 1 hour and a half, to a maximum of 2 hours and a half.

- When technically possible, the exam is partially computerized and consists of:
  a) open questions (definitions/properties/theoretical results) generally on paper, plus multiple-choice questions (on a computer-based platform) always on the more theoretical aspects, for a total weight of 1/3 of the grade of the written exam. For this part it is not allowed to consult teaching materials or other tools.
  b) exercises (on a computer platform) on the application of what has been seen in the course, with possible open questions in which to show concrete examples of application, for a total weight of 2/3 of the grade of the written exam. For this part, the use of **a handwritten form on A4 sheet (one page front and back)** and a non-programmable scientific calculator is permitted.

- The teacher determines the duration of the oral exam, which may serve either to confirm the written exam grade or to assess the material in greater depth. Students scoring below 16 on the written exam are not eligible to take the oral exam. The oral exam score is averaged with the written exam grade; specifically, a student unable to explain the work done in the written exam will receive a score of 0 for the oral component. The same score is assigned to students refusing to take the oral examination on the time and terms decided by the instructor. The oral exam may consist of a discussion regarding the written exam, the laboratory report, topics covered in class, topics covered in class or assigned as individual reading task.

- The instructor may decide to schedule two intermediate tests, one scheduled in mid-term (generally in April) and the other in June. The first test focuses on the first part of the program, the second on the second part. Those who have obtained a mark of at least 14/30 in the first intermediate test are admitted to the second intermediate test. The average grade obtained in the two tests therefore replaces the vote of the written exam.

- In the written / oral exams (as in the intermediate tests) the correctness and completeness of the answers is evaluated. In questions and exercises are evaluated, among other things, the ability to choose appropriate random models, know their characteristic properties, estimate the probabilities or parameters, discuss the properties of the model parameters by testing.

- The online work consists of quizzes and exercises on the e-learning and wims platform and in a group work (optional) in which the concepts of the course are applied to a set of data. In the online work the correctness of the answers given is evaluated (automatically). Since the questions and exercises are similar to the ones in the exams, they evaluate the same skills that are evaluated in the exam (see the previous paragraph). Group work is an analysis of a data set chosen by the students (the data set must be approved by the teacher, who eventually may propose a different data set; the teacher provides examples of data sets among which the students may choose), and delivered through the e-learning platform for correction by the teacher and tutor, which assesses the capacity for critical analysis and application of the concepts of the course to a real case (in particular the ability to extract information from data). The online and group work give a total score from 0 to 7 points (1.5 points if all the quizzes are done at least once with a score of at least 24; 2.5 points if all the wims exercises are done at least once with a score of at least 24; from -1 to 3 the evaluation of the group work).
  The group work must be submitted for evaluation by the deadlines set for the various exam sessions (recall that it is not a compulsory activity). Quizzes and exercises must be completed within 24 hours of the written exam (grades taken into consideration will be those obtained within 24 hours of the exam).
  More details on the online work can be found in the presentation of the course on the elearning page (accessible from the beginning of the course during the academic year).

The final grade is made up of the written grade (+ possibly oral) out of 25 points (multiply the grade by 25/30) to which is added the score of the online work. The score for the online work is not added if the written grade is less than 13.5/25 (or equivalently, 15.6/30).

*The following assessment grid is applied, based on these parameters:*

1. Conceptual knowledge and understanding
2. Ability to apply knowledge and understanding
3. Communication and argumentation skills
4. Learning, self-assessment, and self-regulation skills

**Grade < 18**

1. The student identifies the characteristics of the concepts completely or partially and is unable to formulate a comprehensive and exhaustive explanation of these concepts. The connections between the concepts are absent or fragmented and poorly supported by theoretical references.
2. The student identifies only a few relevant elements, unable to integrate them into a comprehensive

analysis. The explanation is fragmented and lacks critical depth.
3. The student develops a sparse argument, characterized by numerous expository and logical flaws, compromising the correctness and clarity of the discussion.
4. The student is unable to reconstruct none or only some aspects of his or her learning path. Often fails to recognize their own errors and critical points.

**Grade 18-22**

1. The student recognizes and reflects most of the conceptual features and is able to provide a relatively coherent explanation, albeit with some inaccuracies. The theoretical references are not rigorously contextualized.
2. The student is able to recognize a certain number of elements and provide a partial explanation, while highlighting some gaps. The application of knowledge is not always systematic.
3. The student constructs a basic exposition, with a minimal structure but with logical and discursive inaccuracies. The exposition, although understandable to an expert in the subject, sometimes lacks flow.
4. The student demonstrates a basic awareness of their learning path. They are sometimes able to recognize their own inaccuracies.

**Grade 23-27**

1. The student demonstrates a thorough understanding of the course topics, establishing structured and coherent connections. Explanations are well-structured and supported by the use of theoretical references.
2. The student identifies and applies the essential elements of the course, successfully explaining them in a coherent and well-structured analysis. Knowledge is applied with a rigor that is not always solid.
3. The student develops a coherent and well-organized argument, demonstrating mastery of language and a solid logical-argumentative structure. Communication is clear and effective.
4. The student analyzes his or her learning path in a clear and structured manner, demonstrating good critical thinking skills.

**Grade 28-30**

1. The student demonstrates mastery of concepts, articulating connections and providing comprehensive explanations. Theoretical references are used with relevance and rigor. The student is able to replicate the demonstrations of the main facts of the course.
2. The student demonstrates an advanced ability to explain and apply the methods covered in the course. Knowledge is applied with methodological rigor, supported by solid and detailed argumentation.
3. The student develops a solid and detailed argument, with a rigorous logical structure and a high level of textual coherence. The discourse is fluid, well-structured, and free of critical issues.
4. The student demonstrates an advanced capacity for self-reflection, developing a detailed and in-depth analysis of their learning journey. The connections between the theoretical and practical aspects of their learning experience are internalized with great awareness.

## Office hours

By appointment

## Sustainable Development Goals

QUALITY EDUCATION | CLIMATE ACTION