UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

# COURSE SYLLABUS

# Advanced Derivatives

**2627-2-F1602M021**

## Learning objectives

The aim of the course is to provide students with the main mathematical and numerical tools useful for the evalutation of derivatives written on interest rate and equities. The main targets are:

1. Knowing the types of path and non-path dependent .
2. Being able to simulate the dynamics of an equity or of an interest rate
3. Being able to download financial data and to use Bloomberg for pricing non vanilla options.
4. Bootstrapping an interest rate curve and extrapolating of the probability of a default from market data.

## Contents

**Interest Rate Derivatives**

- FRA, Futures, and Swaps
- Rate curve bootstrapping in multi-curve regimes
- Black Model
- Interest rate volatility: par, forward, no-arbitrage, and SABR model
- Term structure models: equilibrium, no-arbitrage, short rate, and market models
- Caps and Floors, Swaptions, and Bermudan Swaptions
- Credit Default Swaps
- Credit curve bootstrap
- Counterparty risk: clearing, collateralization, e XVA valuation adjustments
- Market risk management: greche e replica statica dei prodotti strutturati

**Equity Derivatives**

- Black&Scholes and Ito’s lemma for multivariate functions

- Change of Numéraire technique.
- Exchange and Exotic Options
- Numerical Methods in Finance
- Stochastic volatility models
- Volatility derivatives

## Detailed program

**Equity Derivatives**

*Black&Scholes and Ito's Lemma for multivariate functions:*
Limits of the Black and Scholes model.
Normal Mixture model for option pricing.
Ito's lemma for multivariate functions.

*Change of Numéraire technique:* Introduction to the Change of Numéraire technique.
Derivation of B&S formula using the Change of Numéraire technique

*Exchange and Exotic Options:* Valuation of Exchange options through change of Numéraire.
Exotic Options: path and non-path dependent.

*Numerical Methods in Finance I*

Iterative methods: Bisection, Secant and Newton-Raphson Methods and Calibration problem (Matlab functions: fmincon and fminunc)

Monte Carlo Simulation: Theory, Confidence Intervals and Variance Reduction techniques.
Simulation of sample paths and application for option pricing.

*Numerical Methods in Finance II*
Monte Carlo Simulation for path dependent options.
Binomial and Trinomial tree implementation (an introduction).

*Pricing derivatives in Bloomberg*

Plain vanilla option prices and implied volatility surface
Simulated scenarios for the underlying and pricing of exotic derivatives in Bloomberg.

*Numerical Methods in Finance III*
Finite Difference Approximation: first and second derivative.
Application of the finite difference method for the Greeks.

*Stochastic volatility models* Stochastic Volatility: Derivation of the valuation Equation.
Properties of Stochastic Volatility. Implied Volatility Surface.
Heston Model: simulation, pricing formula and volatility surface.

*Volatility derivatives*
The log-contract replication formula.
Variance and Volatility Swaps. VIX Index: CBOE Formula.

**Interest Rate Derivatives**

- Interest Rate Basics
- Rate Curves Calibration
- Black Model
- Volatility
- Caps and Floors
- Swaptions
- Structured Products
- Greeks and Hedging
- Interest Rate Models
- Bermudan Swaption
- Credit Derivatives
- Counterparty Risk, Collateral Protection and Central Clearing
- Credit Default Swaps
- Credit Curve Bootstrapping
- XVAs: Introduction to Valuation Adjustments
- The Reform of Benchmark Interest Rate Indexes and Its Impact on Derivative Pricing

## Prerequisites

Good knowledge of financial math, derivatives and coding in Matlab.

## Teaching methods

Classes with classical teaching methods and practical interactive sessions (Excel, Matlab and use of the data provider Bloomberg)

Some of the lectures can be provided remotely (at most 30% of the hours) in streaming or recorded. The teacher will communicate in
advance which lessons will be provided remotely.

Most of the lectures and practical exercise sessions (70%) will be based on conventional teaching methods. The remaining 30% of the lectures and exercise sessions will be delivered through interactive methods.

## Assessment methods

Project work and subsequent oral examination

## Textbooks and Reading Materials

Slides provided by the lecturer

**For Interest Rates Derivatives**

J. Hull, Options, Futures and Other Derivatives, 10th edition

Oosterlee, Cornelis W., and Lech A. Grzelak. Mathematical Modeling and Computation in Finance: With Exercises and Python and Matlab Computer Codes. World Scientific, 2019.

P. Wilmott, on Quantitative Finance

**For Equity Derivatives**

J. Hull, Options, Futures and Other Derivatives, 10th edition

P. Glasserman, 'Monte Carlo Methods in Financial Engineering' Springer Science, 2003

## Semester

First Semester

## Teaching language

Italian

## Sustainable Development Goals

QUALITY EDUCATION | GENDER EQUALITY