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# Lecture 1

- ▶ Introduction
- ▶ Background Knowledge, Materials for the course (book etc.)
- ▶ Outline of the Course
- ▶ Grading
- ▶ Financial Engineering
- ▶ Financial Markets and Different Asset Classes
- ▶ Stocks and Dividends
- ▶ Interest Rates
- ▶ Volatility
- ▶ Options & Payoffs

## Lecture 2

- ▶ Trading of Options and Hedging
- ▶ Commodities
- ▶ Currencies and Cryptos
- ▶ Value of Call and Put Options and Hedging
- ▶ Modeling of Asset Prices and Randomness
- ▶ Stochastic Processes for Stock Prices
- ▶ Itô's Lemma for Solving SDEs

# Lecture 3

- ▶ Stock Paths and Simulation in Python
- ▶ Black-Scholes model
- ▶ Hedging with the Black-Scholes model
- ▶ Martingales and Option Pricing
- ▶ Coding of Martingales in Python
- ▶ Risk Neutral Valuation and Feynman-Kac Formula
- ▶ Measures and Impact on a Drift
- ▶ Closed-Form Solution for Black-Scholes model

# Lecture 4

- ▶ Key Elements for Pricing Derivatives
- ▶ Black-Scholes Implied Volatility
- ▶ Newton-Raphson Method and Implementation in Python
- ▶ Time-Dependent Volatility Parameter,  $\sigma(t)$
- ▶ Implied Volatility Surface
- ▶ Deficiencies of the Black-Scholes Model

# Lecture 5

- ▶ Inclusion of Jumps in the Stock Process
- ▶ Poisson Process and Implementation in Python
- ▶ Itô's Lemma and Jumps
- ▶ Jumps and Asset Dynamics under the  $\mathbb{Q}$ -Measure
- ▶ Partial Integro-Differential Equations
- ▶ Different Jump Distributions and Implied Volatility
- ▶ Expectation and Jump Processes
- ▶ Characteristic Function for a Jump Process

# Lecture 6

- ▶ How to Choose a Pricing Method?
- ▶ Fourier Transformation- Motivation
- ▶ Characteristic Function for the Black-Scholes Model
- ▶ Affine Diffusion Processes
- ▶ Characteristic Function for High Dimensions
- ▶ Affine Jump Diffusion Processes

# Lecture 7

- ▶ Towards Stochastic Volatility
- ▶ The Stochastic Volatility Model of Heston
- ▶ Correlated Stochastic Differential Equations
- ▶ Ito's Lemma for Vector Processes
- ▶ Pricing PDE for the Heston Model
- ▶ Impact of SV Model Parameters on Implied Volatility
- ▶ Black-Scholes vs. Heston Model
- ▶ Characteristic Function for the Heston Model



# Lecture 8

- ▶ Fourier Transformation
- ▶ FFT- Fast Fourier Transformation in Python
- ▶ The COS Method and Density Recovery
- ▶ Implementation of the COS Method in Python
- ▶ European Option Pricing with Characteristic Function
- ▶ Pricing Experiments Using COS Method in Python

# Lecture 9

- ▶ Monte Carlo and Integration via Sampling
- ▶ Examples of Stochastic Integrals in Python
- ▶ Smoothness of a Payoff and Impact on Convergence
- ▶ Types of Convergence
- ▶ Option Pricing and Standard Error
- ▶ Euler Discretization
- ▶ Milstein Discretization

# Lecture 10

- ▶ Option Pricing with Monte Carlo
- ▶ Simulation of the CIR Process
- ▶ Exact Simulation of the CIR Model
- ▶ Almost Exact Simulation of the Heston Model
- ▶ The Heston Model and Simulation in Python

# Lecture 11

- ▶ Hedging with the Black-Scholes Model
- ▶ Dynamic Hedging- Python Experiment
- ▶ Hedging with Jumps
- ▶ Delta, Gamma and Vega Hedging
- ▶ Monte Carlo Sensitivity: Finite Difference
- ▶ Monte Carlo Sensitivity: Pathwise Sensitivities
- ▶ Monte Carlo Sensitivity: Likelihood Ratio Method

# Lecture 12

- ▶ Forward-Start Options
- ▶ Characteristic Function for Pricing of Forward Start Options
- ▶ Forward Start Options under the Black-Scholes Model
- ▶ Forward Start Options under the Heston Model
- ▶ Forward Implied Volatility with Python
- ▶ The Bates Model
- ▶ Variance Swaps

# Lecture 13

- ▶ Overview of Payoffs in the Industry
- ▶ Binaries and Digitals
- ▶ Path-Dependent Options: Barrier Options
- ▶ Asian Options
- ▶ Multi-Asset Options