**NC STATE UNIVERSITY**

# 2026 Winter High School Online Research Academy
# Financial Derivatives Pricing in the U.S.

## COURSE OVERVIEW

In the finance services industry, a derivative is a contract whose valuation is derived from another asset's price. For example, a call option on common stock: a call on Microsoft stock (MSFT) gives the holder the right to buy MSFT at a predetermined strike price. Markets for derivative products are mainstay in the modern financial services industry. Typically, a large financial institution will employ professional traders whose job is the brokering, sale and creation of derivatives. In Q1 of 2024, derivative products in the U.S. had a total notional of $206 trillion. Some of these derivatives are speculative positions of investors betting on the direction of price movements, but the majority are part of the risk-management strategies of large corporations who are using these derivatives as insurance instruments –-a practice commonly referred to as 'hedging'.

## COURSE OBJECTIVES

This 4-week research program is designed to introduce high-school students to the basic mechanics of derivative pricing. Students will
- gain basic understanding of derivatives and their risks
- be familiarized with the Black-Scholes formula and it uses for valuation of derivatives.

In particular, the course covers (i) structure and operation of derivative markets, (ii) valuation of derivatives, (iii) hedging of derivatives. Models and pricing techniques include binomial trees and Black-Scholes model. Specific topics include simple no-arbitrage pricing relations for forward contracts; put-call parity relationship; implied volatility and statistical properties; dynamic hedging strategies; pricing of fixed-income product.

# 4-Week Plan

This program starts with very basic concepts from fixed income (e.g., borrowing and lending at fixed rates), and then moves on to stocks and basic portfolio construction. After building this foundation, we will learn about how the lack of risk-free profit can be used to determine arbitrage-free prices for derivatives, and then finally we will use some basic models to obtain benchmark prices.

| Week | Topic |
|------|-------|
| **Week 1** | Introduction, mechanics of trading |
| **Weeks 1 - 2** | Time value of money, interest rates, bonds, arbitrage |
| **Weeks 2 - 3** | Investing in equities, forward contracts, call and put options, properties of options, hedging |
| **Weeks 3 - 4** | Binomial trees, Black-Scholes-Merton model |
| **Week 4** | Implied volatility, option Greeks |

The actual schedule might change, depending on how fast/slow we will be able to cover the ground.

## NECESSARY BACKGROUND

- Pre-calculus
- Basic probability (coin flipping and games of chance)
- Students must have had some exposure to Python/Matlab programming (e.g., Numpy and PyPlot) and must have a working Python/Matlab environment on their local machine or have access to cloud-based computing tools.

# FINAL PROJECT

In addition to the weekly readings assigned, there is a final project that consists of two parts:

1) 4 weekly homework assignments that will test students' understanding of the materials covered.
2) Development of Python or Matlab toolbox for option pricing algorithms. In the case of Python, this toolbox will be presented in a Jupyter notebook, viewable in PDF with student's written comments and interpretation of the output.

**The final project will be due March 6.**
**The graduation ceremony for the course will be held March 12.**

**Grading:** This course is offered on a pass/fail basis. Students must complete the final project by the due date. Failure to attend all 8 sessions of the course without extenuating circumstances may compromise your ability to complete the course

# COURSE MATERIALS

Helpful (but not required) Textbooks

1. Hull, John C., **Options, Futures, & Other Derivatives**, 11th edition, Pearson Education, 2022

and for more mathematical treatment

2. Capinski, Marek and Zastawniak, Tomasz, **Mathematics for Finance: An Introduction to Financial Engineering**, 2nd edition, Springer, 2011

# COURSE INFORMATION

**Course Website**:

Meeting Time: Monday and Wednesday 7-8 PM EST

Lectures are held '**Week day'** between "Time" on Zoom (the link can be found on thecourse website).