

DRP Proposal

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October 18, 2025

1 Topic Outline

1. Implementation of European option pricing through Black-Scholes closed-form, Monte Carlo Simulations and applying variance reduction techniques to improve accuracy.

(a) May explore option pricing using ML models as well.

If there's extra time

2. Brief look into implied volatility and realised volatility.

(a) Volatility arbitrage strategy using delta-hedged straddles on equity index options.

(b) Evaluate Sharpe ratio, drawdowns, CVaR, and other risk-adjusted metrics.

2 Project Goals

Part I — Option Pricing (Sell-Side)

1. Develop a solid understanding of the mathematical foundations of the Black-Scholes model, including assumptions and derivation of the PDE.
2. Implement Monte Carlo simulation methods to price European call and put options.
3. Evaluate accuracy and convergence of Monte Carlo estimators versus analytical Black-Scholes prices.
4. Apply variance reduction techniques (antithetic variates, control variates, quasi-Monte Carlo) to improve estimator efficiency.
5. *(Optional)* Compute and interpret option Greeks ($\Delta, \Gamma, \Theta, \text{Vega}, \rho$) via simulation.
6. *(Optional)* Explore machine learning-based pricing models (e.g., regression, XGBoost, neural networks) and benchmark their performance against traditional methods.

***(Optional)* Part II — Volatility & Strategy (Buy-Side)**

1. Examine the relationship between implied volatility (from option prices) and realised volatility (from historical returns).
2. Construct a delta-hedged straddle strategy to isolate exposure to volatility.
3. Backtest the strategy using historical data on equity index options (e.g., S&P 500).
4. Evaluate performance using risk-adjusted metrics such as Sharpe ratio, Sortino ratio, draw-downs, and CVaR.

3 Resources

- Lecture notes
 - Introduction to Option Pricing Y3, SDE for financial Modelling Y3
- GitHub
 - <https://github.com/Scott-Yap/Directed-Reading-Programme> *TBC*

Will try to look for more as we go along the project.

4 Indicative Prerequisites

- ODEs
- Probability and Stats

5 Possible checkpoints

1. Sufficient prerequisite checks
2. Understanding the basics of Options
3. Practical Implementations
4. Colloquium end of term