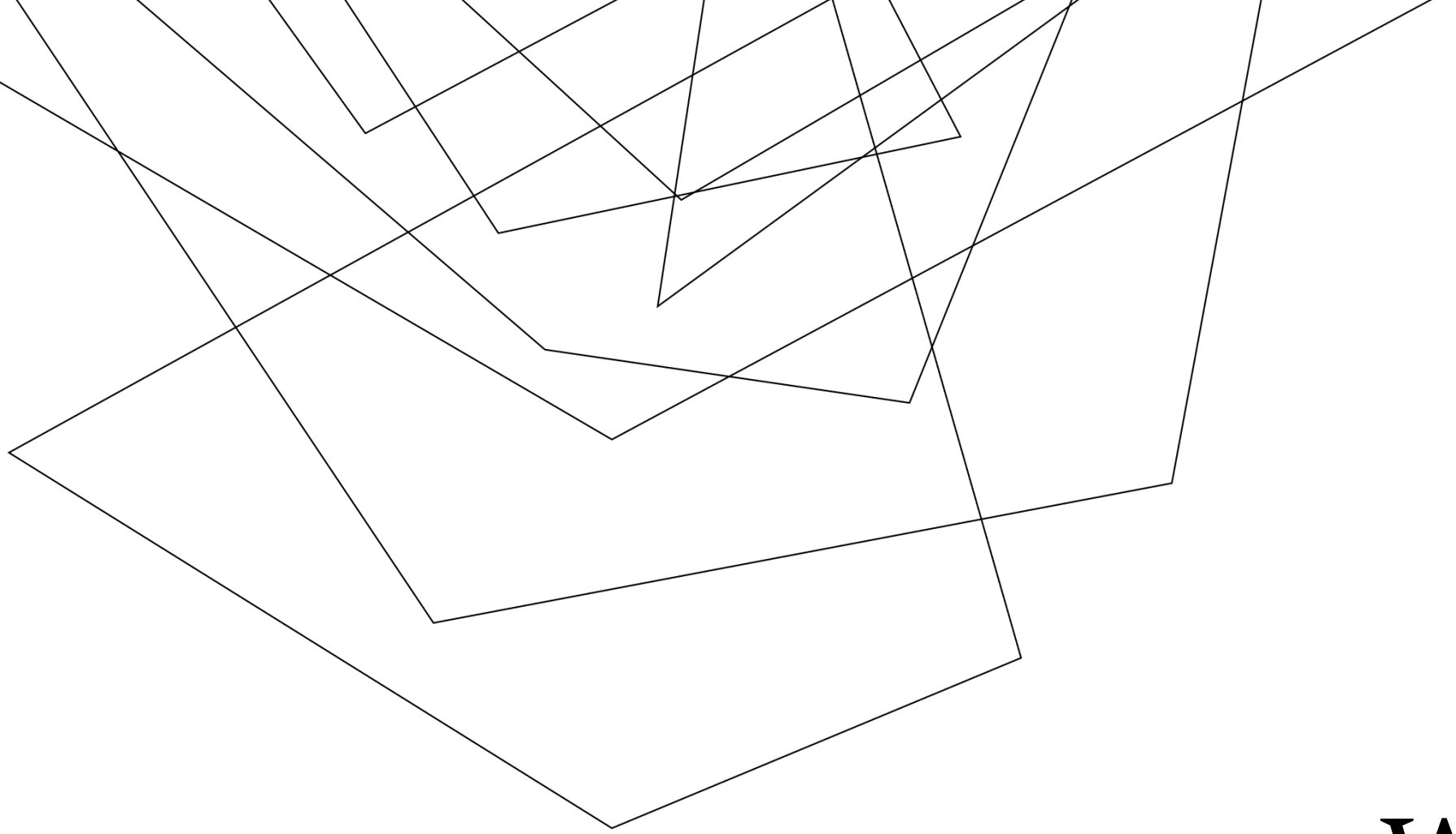

CWRU Quants
quants@case.edu

Welcome!
Please, have a seat.

Attendance | CampusGroups

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AGENDA

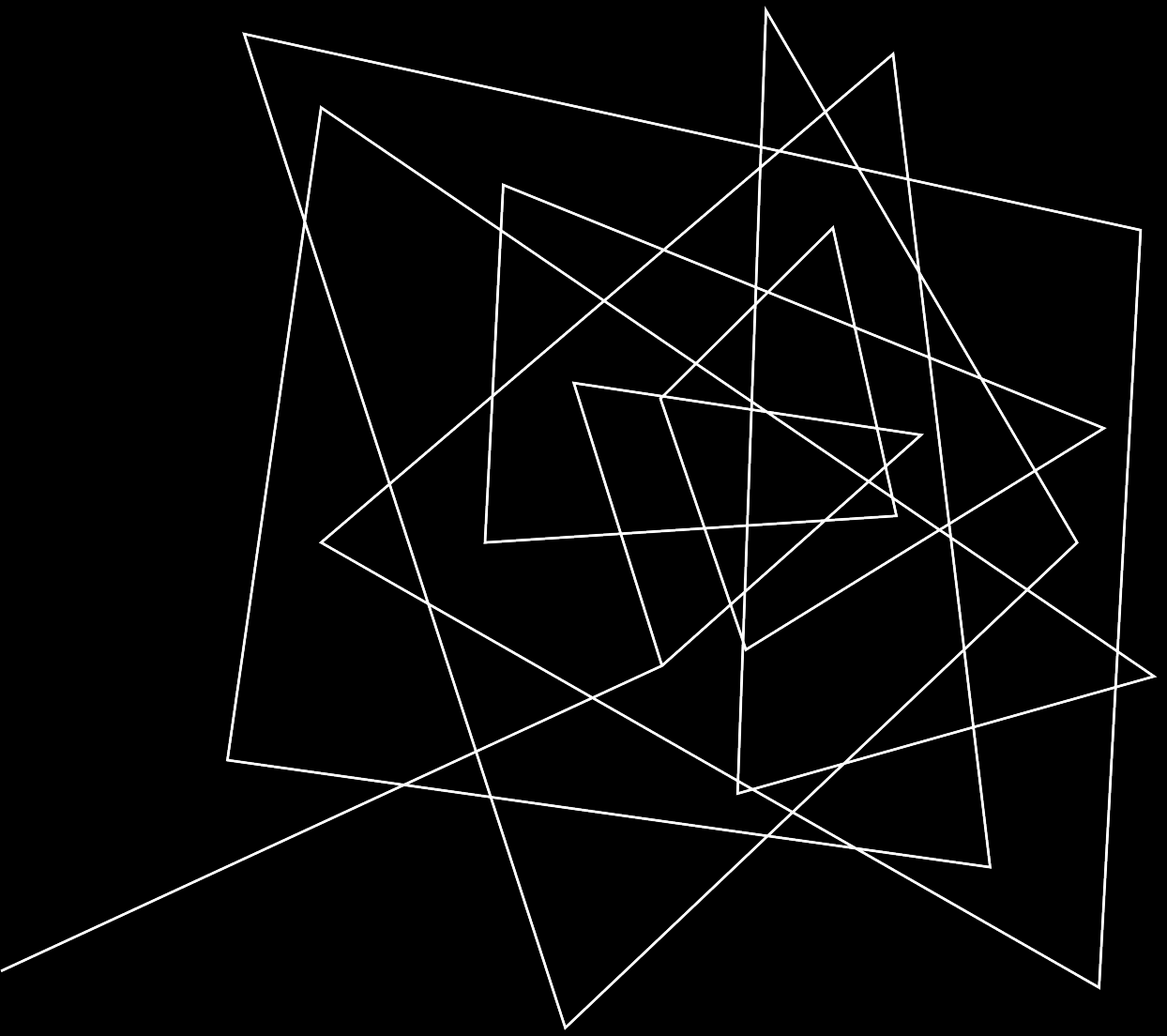
Roadmap

Applications of STEM

Resources

Questions and Answers

Roadmap



CS IN QUANT

High Frequency Trading

- The most CS-intensive subfield of quant
- Highly optimized algorithms meet highly specialized and performant hardware to transact many orders very quickly
- This is how (some) quant strategies are carried out in the market
- Improves liquidity and bid-ask spreads
- Examples: Citadel, Akuna, IMC

Computer Science provides the tools, techniques, and framework to efficiently solve problems in quant finance.

Data Structures and Algorithms

Data Structures

- Know how data structures are implemented under the hood
  - ex. hash table components
- Implementation trade-offs
  - Implementation is often done in-house
- Know how these implementations interact with underlying system
  - Cache hits/misses, vtable lookup, data hierarchy, etc
  - Also important to recognize language differences - how does a Python dictionary differ from a C++ std::unordered_map?

Algorithms

- Efficient space/time complexity is crucial, since low latency is crucial for low execution time
- Intelligent time complexity analysis – don't forget the constants!
- From sorting to searching to DP to greedy
- ML algorithms also crucial, such as SVM, decision trees, neural networks
  - Useful for market prediction based on historical data
- Boost library, STL algorithms

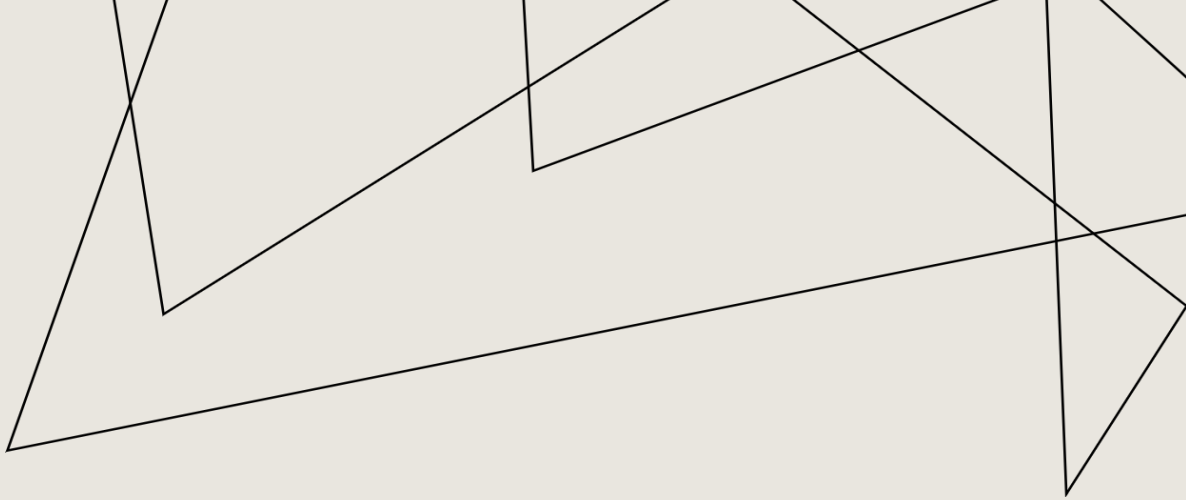
Operating Systems and Computer Architecture

Operating Systems

- Concurrency is critical
  - At the OS level: Threads, processes, context switching, sending and sharing data, scheduling
  - At the application level: Mutexes, locks, semaphores, forking/joining, asynchrony, futures
- Memory management
  - Stack and heap, memory allocation, virtual memory and physical memory, page/frame size

Computer Architecture

- Memory hierarchy
  - Registers, caching (locality, hit/miss, performance),
- Concurrency
  - Hyperthreading, SIMD, CUDA
- FPGA
  - Verilog/HDL
  - Up to 1000x faster execution with custom FPGA hardware



Distributed Systems

Data Pipelines and Processing

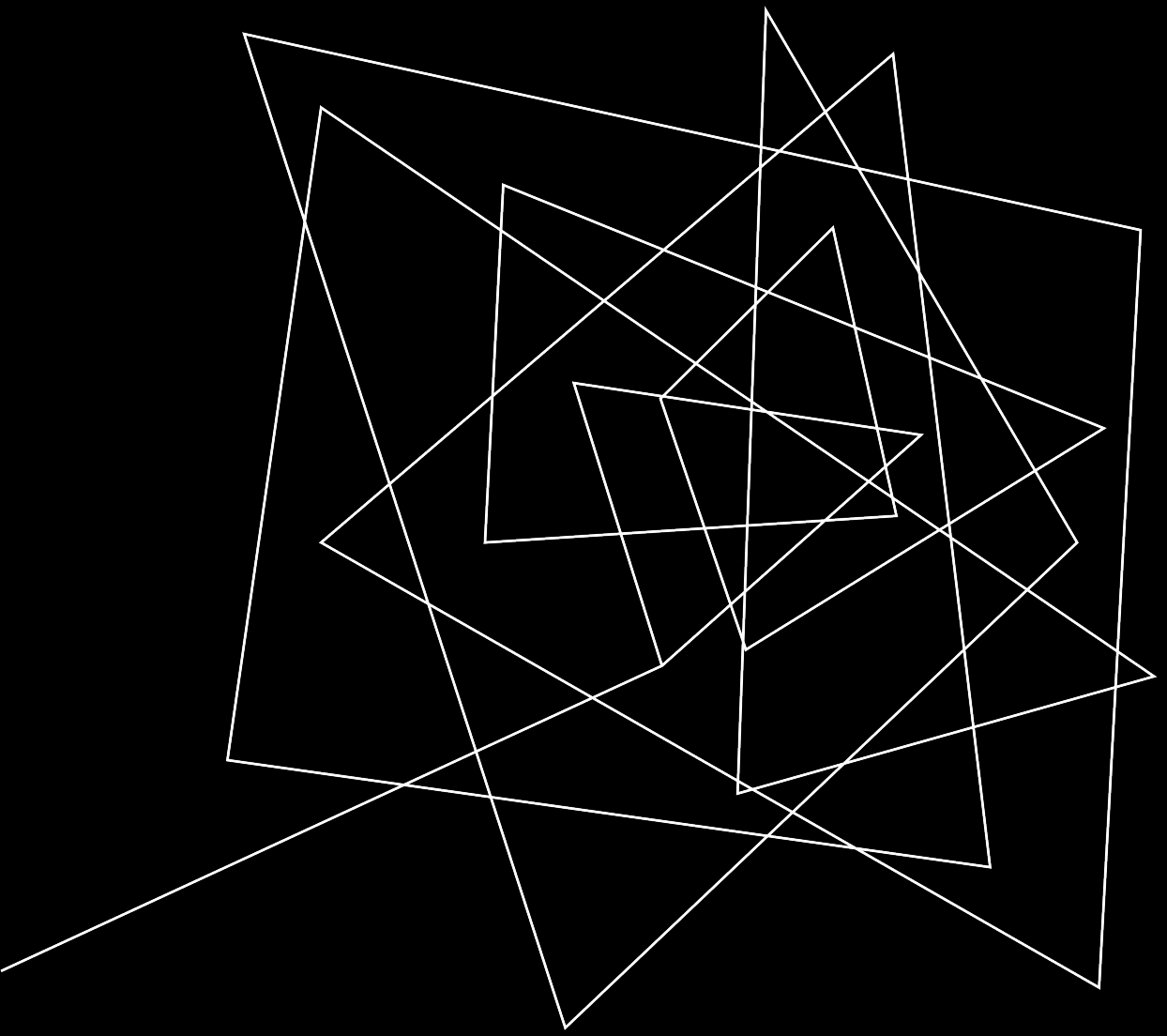
- Linux skills are paramount
  - Shell/terminal, scripting,

Networking

- Precision Time Protocol (PTP)
- Async IO
- Linux network stack (sockets) – at the C and OS level
- Hardware (cables, crossbar fabric switching)

Software Engineering

- It's important to have an idea of what your code compiles into
- Clean, scalable code
- Language-specific tips and tricks to save on time or memory
- Design patterns (object-oriented, functional, etc)
- Safety (memory safety, RAII, thread safety)



MATH IN QUANT

What Math concepts are used in QF?

Core Topics

Calculus, Linear Algebra, Probability and Statistics, Discrete Math

Intermediate Topics

Ordinary/Partial Differential equations, Optimization, Times Series Analysis

Advanced

Stochastic Processes, Various modeling courses

Motivating Question: How can we predict the way options behave?

Let's work through this together! We want to know how how option prices *change* relative to other also changing quantities. Well, we should probably look at some differential equations, because these are things that relate some changing quantities to other changing quantities.

- In finance, it's often useful to ~~steal~~ borrow ideas from physics to help guide us!
- Let's look at a type of differential equations called parabolic partial differential equations (PDEs)

Parabolic Second Order Partial Differential Equations

This is a lot of words! Let's break each one down to understand what the whole thing means. We already know that "differential equations" means expressing the way things change…so what does the rest add?

- Partial → Lets us express quantities as changing w.r.t. different things
- Second Order → We're looking at the changes of something *and* the change of the change of something, but nothing more than that (e.g. velocity and acceleration)
- Parabolic → Adds a condition to being second order, specifically that if the general form of a second order PDE is

$$Au_{xx} + 2Bu_{xy} + Cu_{yy} + Du_x + Eu_y + F = 0$$

then B^2 - AC = 0.

  - This condition lets us focus on special applications!

Examples of Parabolic Second Order PDEs

- One of the most famous examples of Parabolic Second Order PDEs is the *heat equation*, which tells us how the the heat of a thing is distributed over its surface over time
- Another very important example is the time-independent Schrodinger Equation
- But, this is not physics club! Inspired by these cool applications, we want to have our *own* super famous Parabolic Second Order PDE...

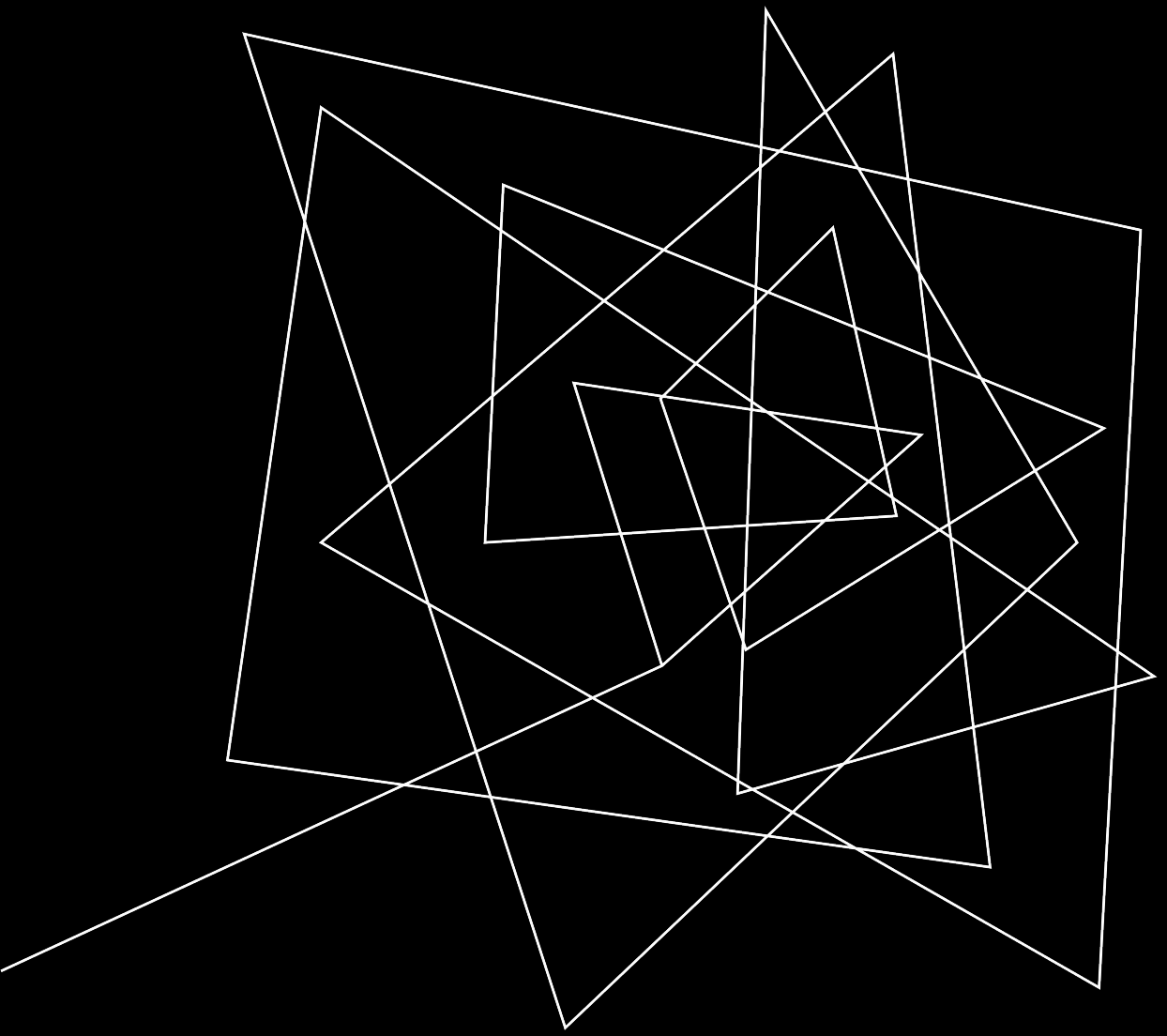
The Black-Scholes Equation

- This is one of the most important equations in finance!
- Fischer Black and Myron Scholes won the 1997 Nobel Prize in Economics for their formulation of this equation, which is used in options pricing

$$\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} + rS\frac{\partial V}{\partial S} - rV = 0$$

- Here, V is the price of our option, t is time, S is the value of the underlying asset, and then we have some constants that are useful for relating these quantities

Main Takeaway: By understanding our goal (estimating the value of a changing quantity), translating it into mathematics, and drawing inspiration from other fields, quants create models that help us achieve our goals.



DATA SCIENCE IN QUANT

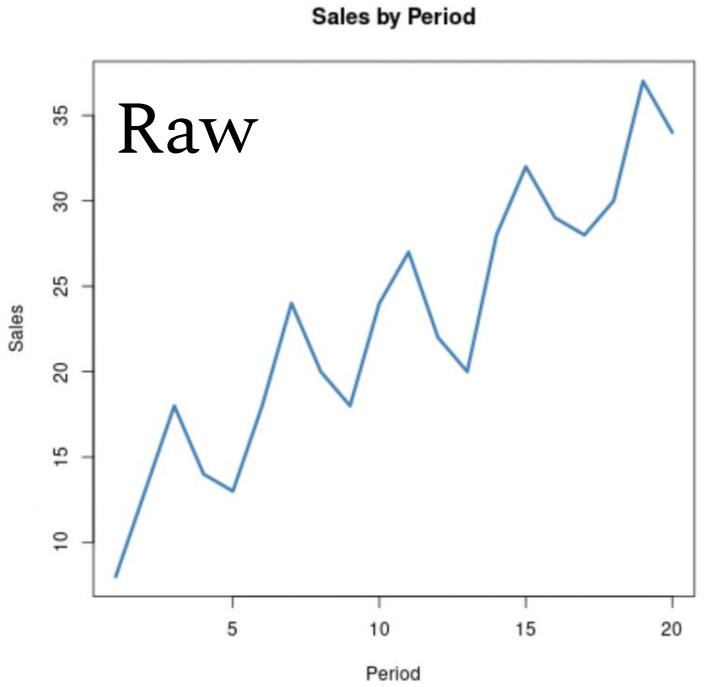
What is Data Science?

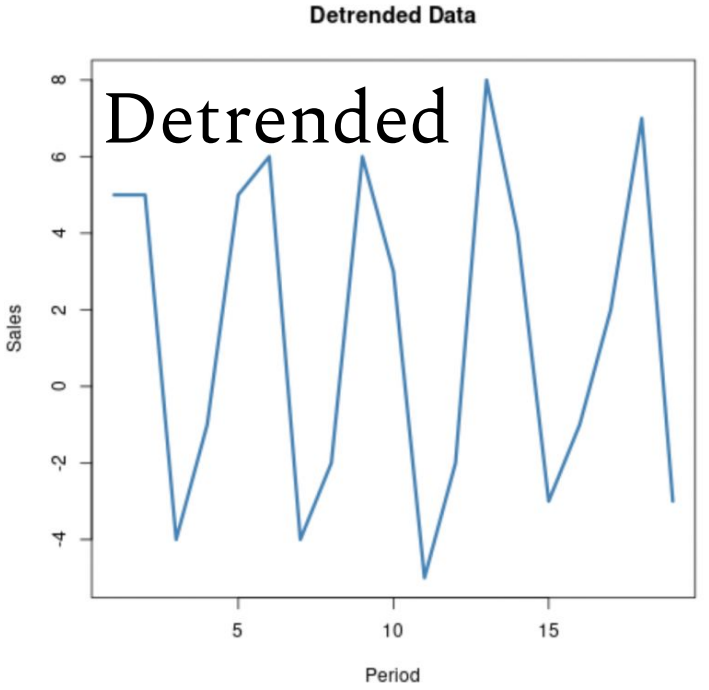
- Data scientists *explore*, *visualize*, *analyze*, *model*, and *present* data
  - Most financial data is structured as a *time-series* (data indexed by time)
  - How do they communicate technical insights with non-technical language? What about translating data insights into business decisions?
  - Real-world data is uncertain and academic models are merely guides
- ***EMERGING FIELD:*** "Business Scientist"
  - Combines the analytical rigor of data science with the strategic mindset of a business professional

'Quant' is somewhat secretive: if you have profitable methodology, why share it?

Golden Rule: Data Quality is King

- Garbage In → Garbage Out
  - Model cannot be accurate without proper historical data
- Data Wrangling and Cleansing
  - Normalization (Apples-to-apples)
  - Detrending (Reveal cyclical/secular phenomena)
  - N/As? Types? Missing Values?
- **How to find financial data @ CWRU?**
  - Wharton Research Data Services
  - Journal of Applied Finance
  - Compustat
  - Pitchbook
  - CRSP



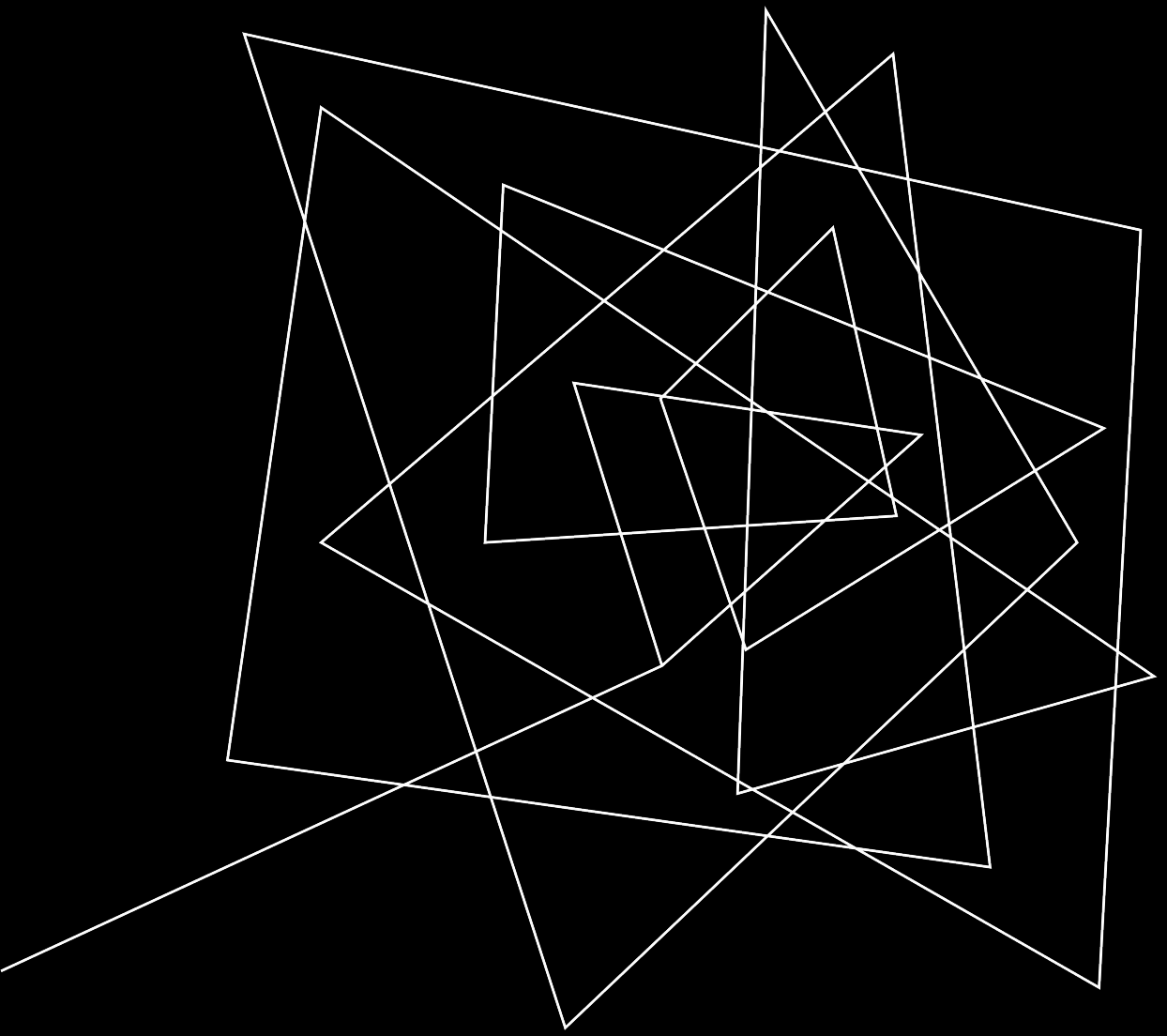


What should you have in your toolbox?

Tools:

- **R** *(tidyverse)*
  - Statistical analysis
- **SQL** *(many different flavors)*
  - Queries
- **Python** *(sklearn, numpy, pandas, scipy)*
  - Machine Learning
  - Data Analysis
  - Scripting
- **Java**
  - Business Logic
- **C++/Rust:**
  - Low-latency applications
- **Excel**:
  - Spreadsheet work

- **Git**
  - Version control
- **UNIX**
  - Simulations
  - Development
- **Communication Skills**



FINANCE IN QUANT

How does traditional finance play into quant?

- **Markets:** Equities, fixed income, commodities, foreign exchange, real estate, crypto, insurance
- **Instruments:** Stocks, bonds, futures, options, swaps, interest rate derivatives, exotic derivatives, crude oil futures,
- **Concepts:** Macro, pricing models, time value of money (TVM), arbitrage, portfolio theory (MPT, CAPM)
- **Players:** Investment Banks, hedge funds, prop firms, market makers, exchanges, asset managers, central counterparty (CCP)

SIMPLY: **FINANCE IS THE APPLICATION**

Instruments Break Down

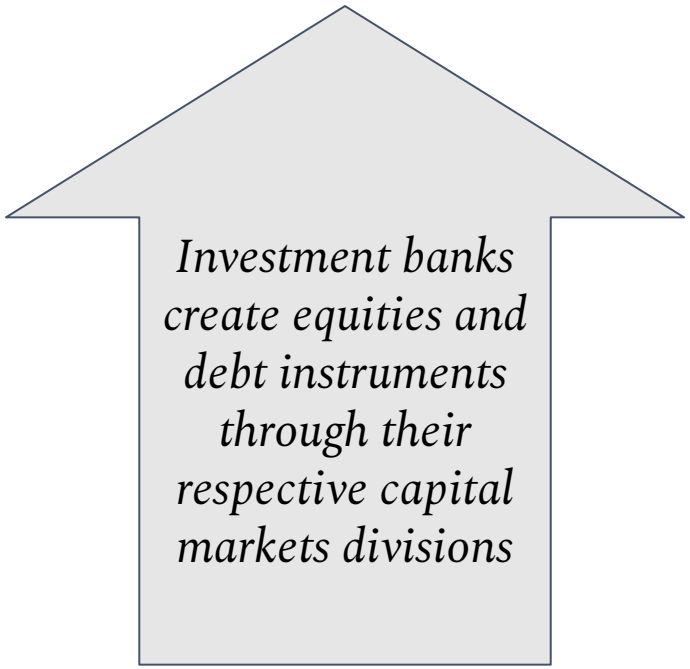
Stocks
Represents ownership of company, most common focus of quant finance, measured with alpha in bips

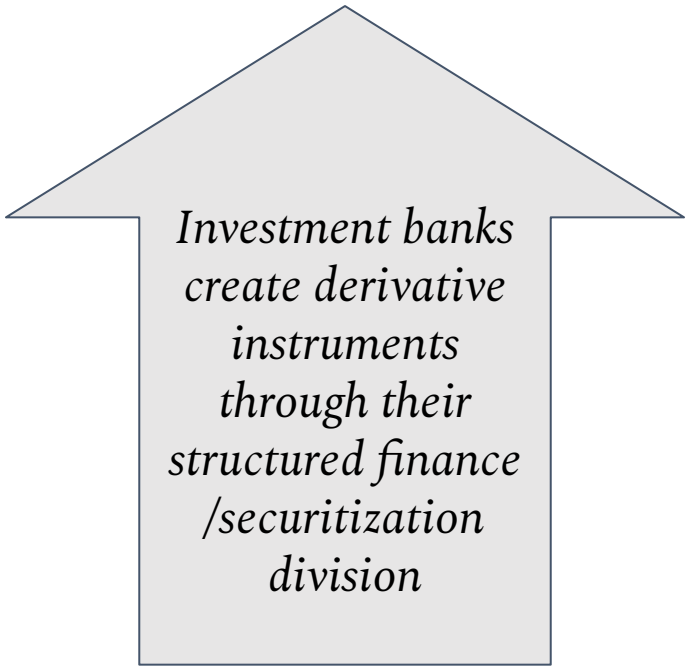
Bonds
Represents a debt obligation, crucial for fixed income markets, measured with yield in bips

Derivatives
Broad category of instruments derived from an unlying asset (stocks, bonds, interest rates, etc)

Swaps
Represents the exchange of cash flows from different instruments (interest rates)

Etc...
Securitization teams at investment banks are able to create custom instruments and asset-backed securities





Categories in Quant Finance

Hedge Funds	Proprietary Trading	Market Makers
- Use investor money - Use leverage, long/short, derivative positions - Active risk management (hedging) - Use machine learning models, backtesting, economic indicators, to generate returns	- Trade their own capital - High frequency trading, short-term trading, statistical arbitrage - Requires: low latency system, good network infrastructure, complex trading strategies	- Provide liquidity to markets by offering to buy/sell securities at any time - Profit from bid/ask spread on trades - Responsible for handling huge amounts of market data, and matching trades at high speed for traders

What can YOU do?

Learn

- Trading competitions
- Courses
- Projects
- If you are genuinely interested and learn 1% every day, you will succeed

Apply

- Fellowships
- Internships
- Conferences
- Tournaments

List of quant trading events and competitions for students (LinkedIn)

QUESTIONS AND ANSWERS

Contact us!

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Attendance