Introduction

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Table of Contents

About this 101 Course

- introduces you to the essentials of ℚuantitative Finance models
- provides a **three-principle framework** to navigate through the forest of mathematical models
- applies and enhances your pre-U (IB, JC, Poly) mathematics to solve ℚF problems
- provides early exposure to the gap between mathematical models and practical realities
- connects and relates theoretical concepts of ℚuantitative Finance (ℚF) with methods used by practitioners
- creates moments of Aha! (Eureka!)

Learning Objectives

By the end of this course, you will be able to acquire the knowledge and attain the comprehension of the following topics in a **three-principle framework**, leading to the application, analysis, synthesis, and evaluation of $\mathbb{Q}$F models and real-life problems.

Financial Instruments

- Underlying assets
  - No maturity: equity, FX, and commodity
  - With maturity: fixed income
- Derivatives
  - Linear payoff: forward, futures, and swaps
  - Nonlinear payoff: options

Learning Objectives (cont'd)

Financial Models

- Interest rate, duration and convexity, yield curves, swap curves, discount factors
- CAPM, APT
- The Black-Scholes pricing model, binomial tree

Financial Mathematics

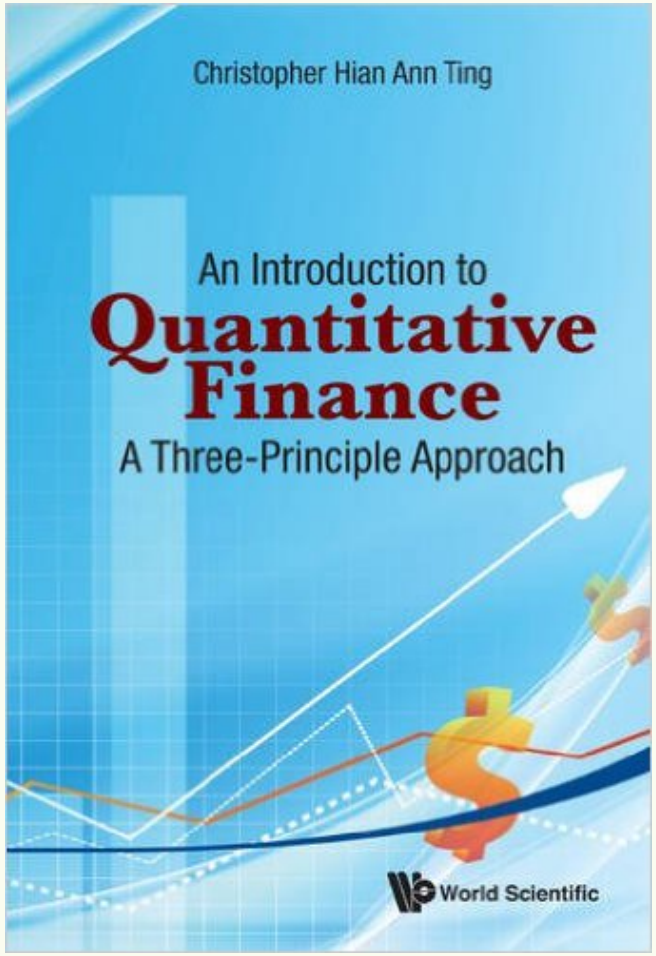
- Random walks
- Einstein's theory of Brownian motion, Bachelier's probability law, geometric Brownian motion
- Itô's calculus
- Model-free methods and results: put-call parity, VIX

ℚF Problems Handled by Quants

- Data sourcing and processing
- Construction and modeling of swap curves
- Model validation
- Replication of payoff function
- Hedging risks
- Sensitivity analysis (“Greeks”)
- Risk-return optimization
- Simulation tests

Study Materials

- Weekly slides
- Additional examples
- Weekly assignments
- Additional exercises
- Practitioners' papers
- Two other reference books
  - Introduction to Quantitative Methods for Financial Markets by Binder et al
  - A Primer for the Mathematics of Financial Engineering (2nd Edition) by Stefanica



Required Textbook

How to Study

- Never skip a class or come late for class
- Solve problems in weekly daily assignments
- Ask questions to clear your doubts in class (class participation!)
- More importantly, always question the models in view of the real world
- **Think like a professional quant!**

Assessments

- Class participation: 10%
  - Attend full 3 hours per weekly session
  - Ask questions in class
  - Discuss on elearn
  - Presentation of MCQs on QF 101
- Blended learning: 5%
- Assignments: 25% (deadline typically in a week's time)
- Quiz tests: 15%
- Final exam: 45%
  - MCQs and short questions
  - Closed book but cheat sheets allowed

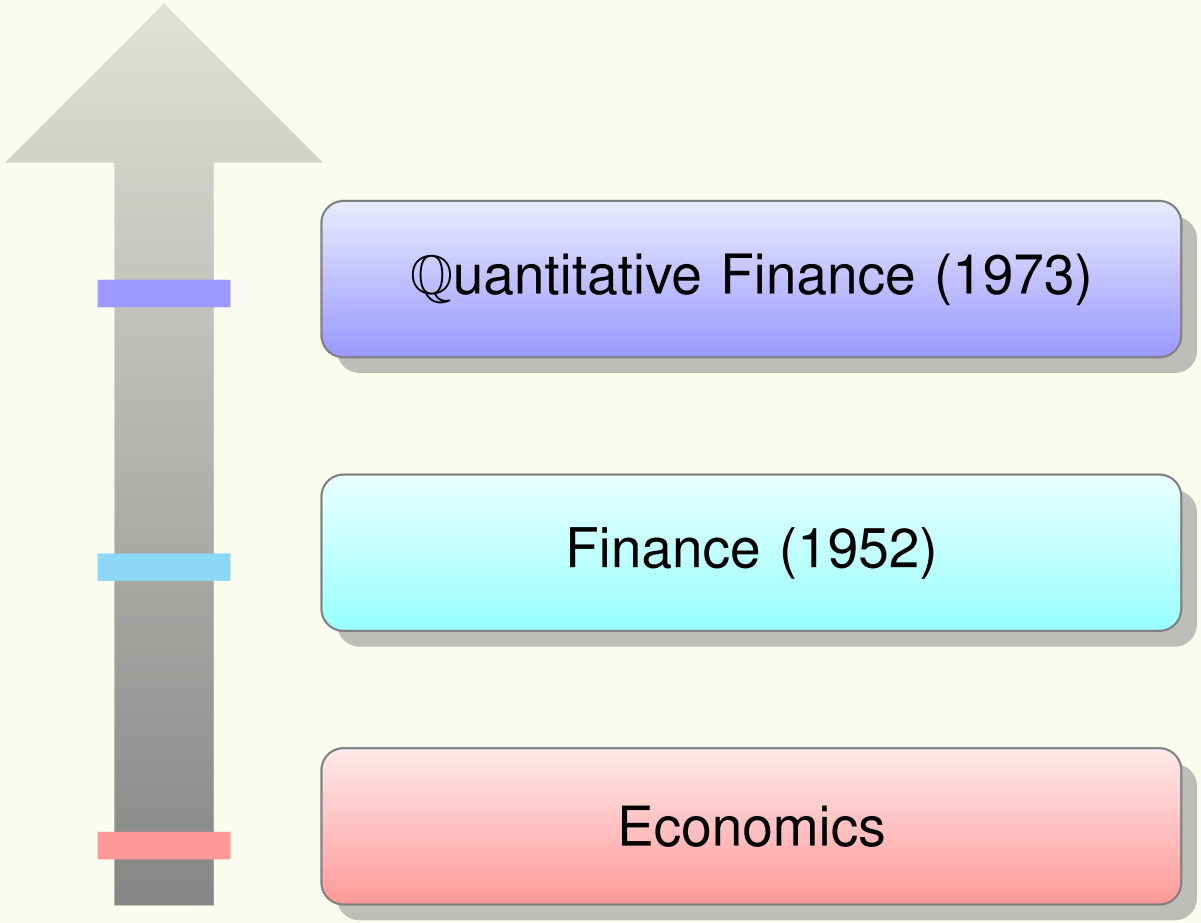
Getting Help

- Informal discussion sessions in between formal classes.
- Office hours: drop me an email a few days in advance
- Teaching assistant

Knowing Your Progress in This Course

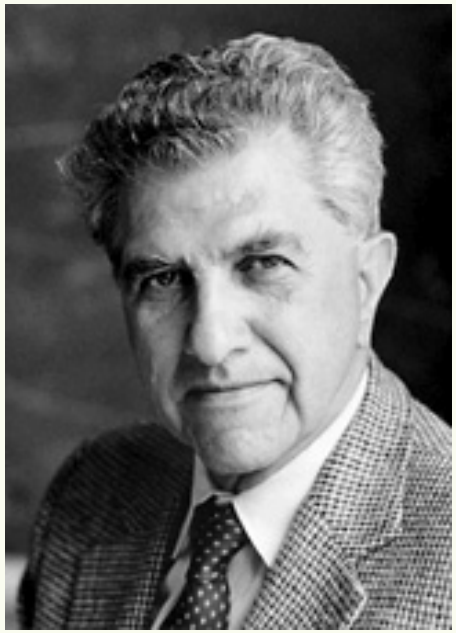
- Solutions to weekly assignments
- Examples covered in class
- Quiz test
- Mock exam paper

Brief History of ℚuantitative Finance



Beginning of Modern Finance

... the very beginning of modern finance—from our big bang, as it were—which I think we can all agree today dates to the year 1952 with the publication in the Journal of Finance of Harry Markowitz's article "Portfolio Selection."



Merton Miller

Picture source: **Nobelprize.org**

Beginning of Modern Quantitative Finance

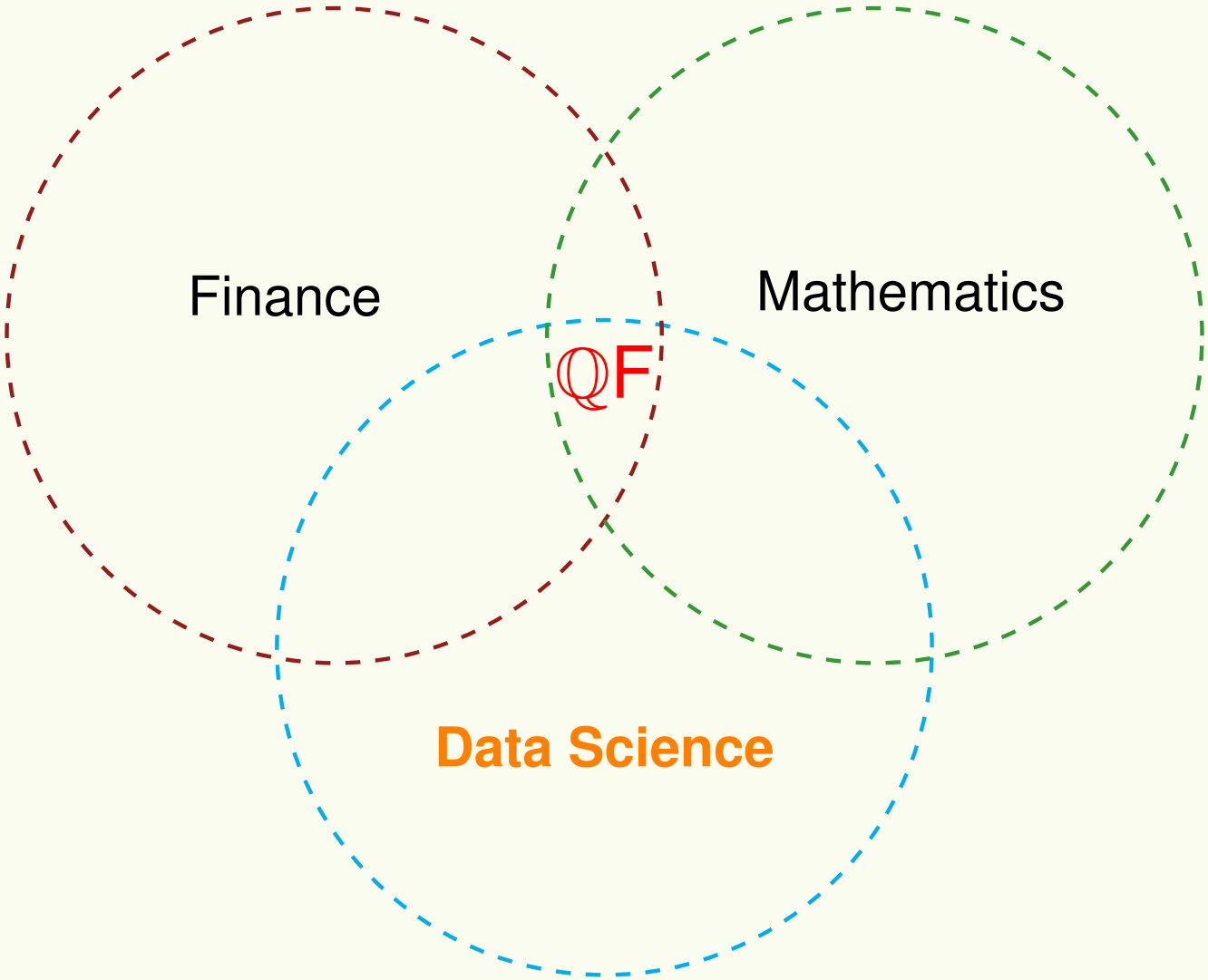
- "The Pricing of Options and Corporate Liabilities" by Fischer Black, and Myron Scholes, 1973

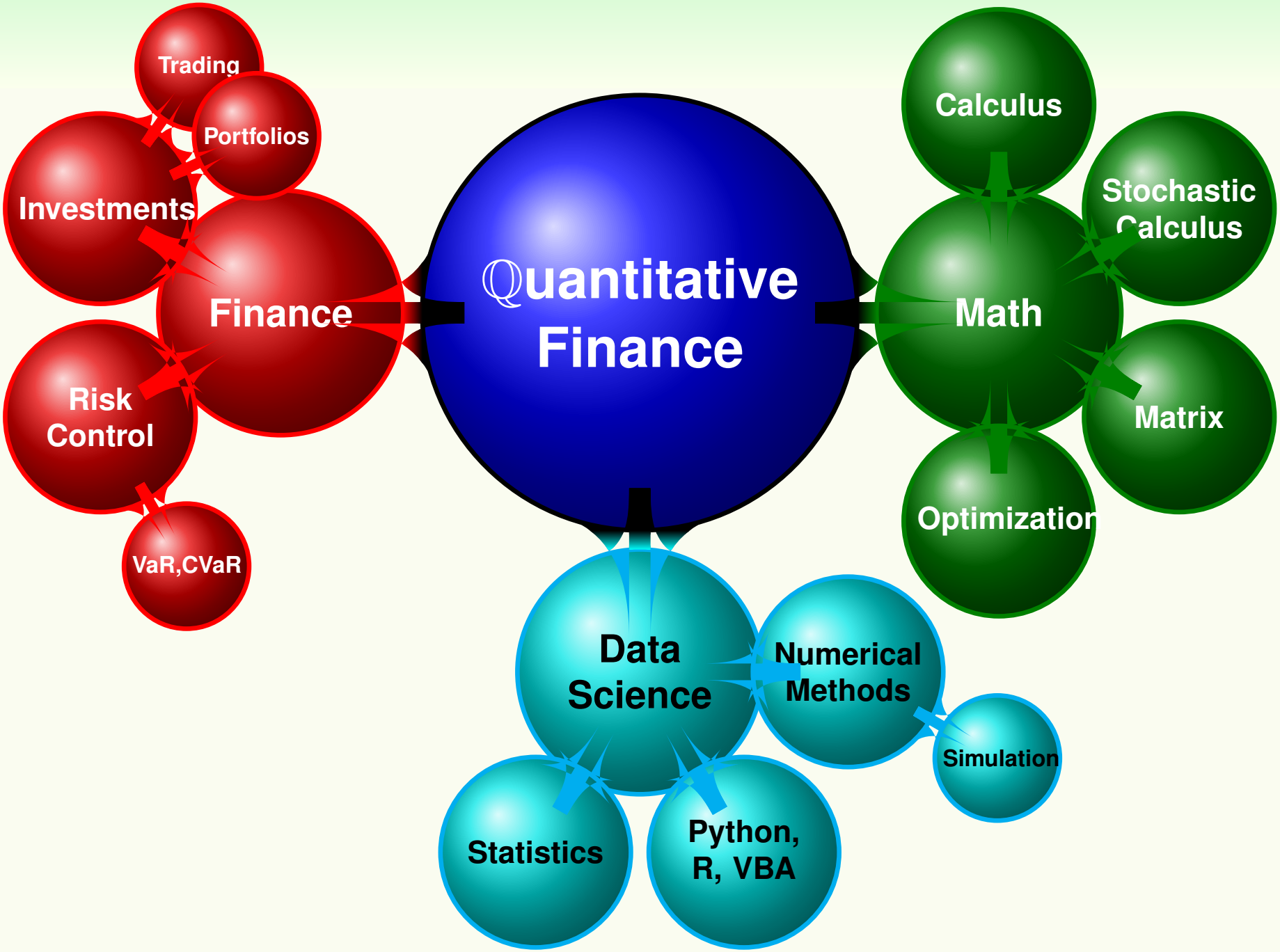
$$\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} + rS\frac{\partial V}{\partial S} - rV = 0$$

- First ever application of **stochastic calculus**

Kiyoshi Itô

Quantitative Skills for Finance




Quantitative Finance
Finance
Trading
Portfolios
Investments
Risk Control
VaR,CVaR
Math
Calculus
Stochastic Calculus
Matrix
Optimization
Data Science
Numerical Methods
Simulation
Statistics
Python, R, VBA

Quantitative Finance

In a nutshell, Quantitative Finance is a discipline devoted to applying the eclectic mathematical and statistical models to tame risks *and* generate alpha in the setting of a financial institution.

Definition of QUANT: an expert at analyzing and managing quantitative data

Merriam-Webster Dictionary

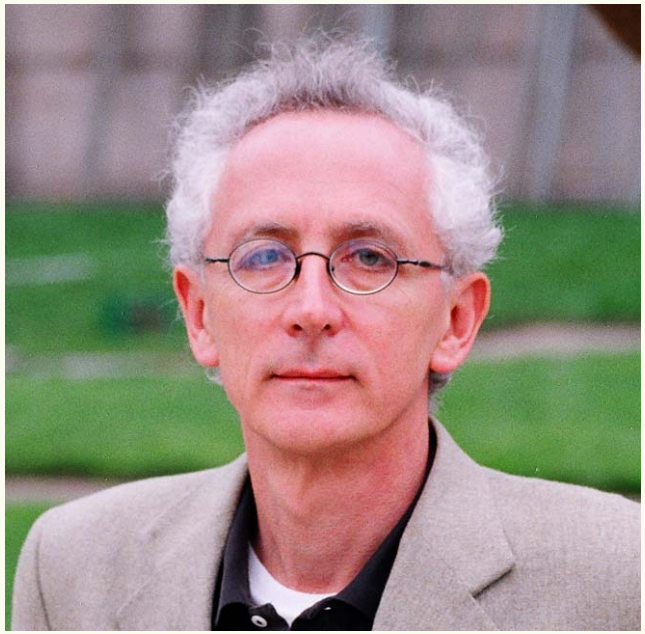
Why Data?

- Trading systems don't care what the answers are: We will let the market tell us the answers by what it does.
- Strategy is easy, execution is hard.
- Our approach is very different. We don't start with models. We start with data. We don't have any preconceived notions. We look for things that can be replicated thousands of times.

James Simons

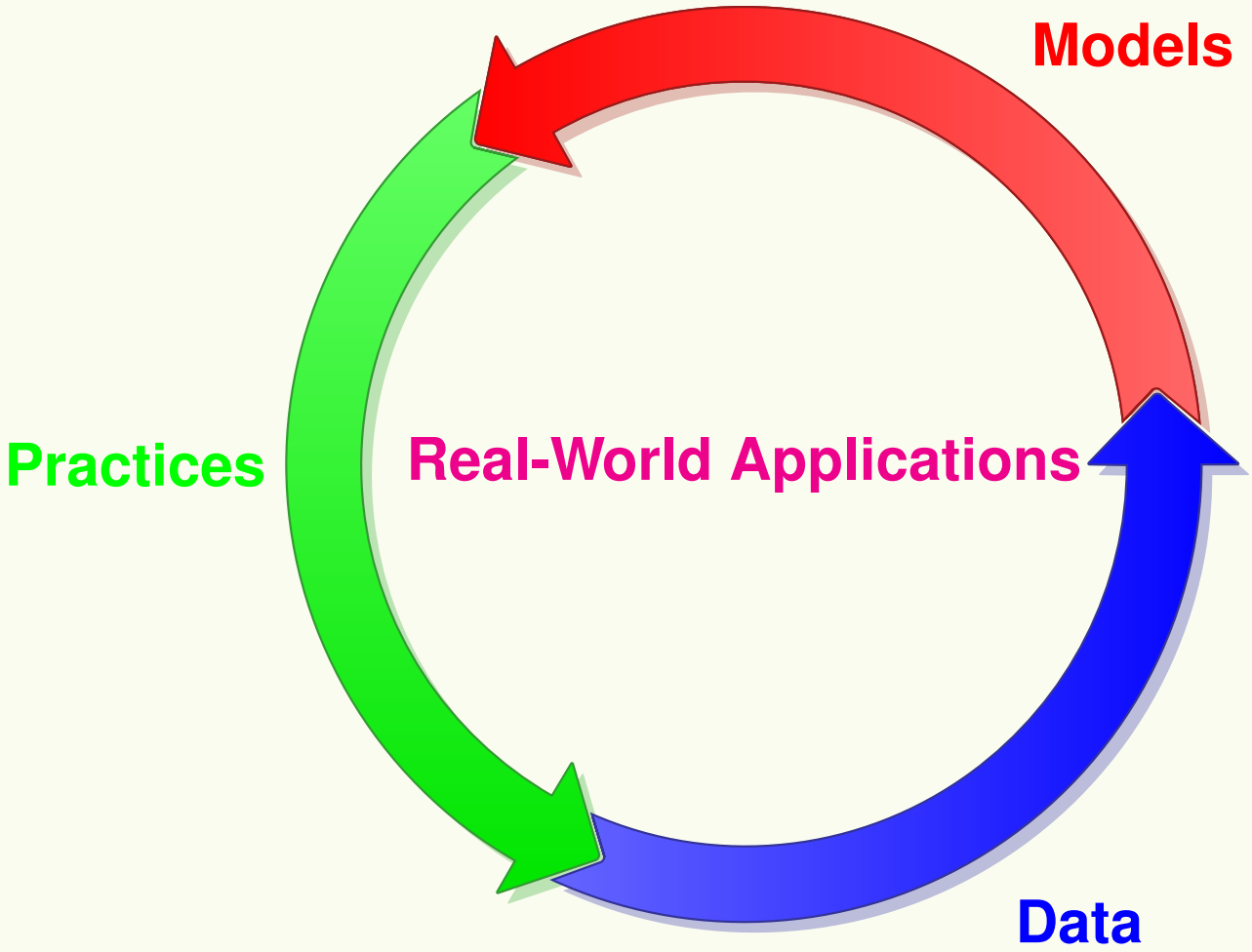
Emanuel Derman Said

Quants and their cohorts practice "**financial engineering**"—an awkward neologism coined to describe the jumble of activities that would better be termed ***quantitative finance***. The subject is an interdisciplinary mix of physics-inspired models, mathematical techniques, and computer science, all aimed at the valuation of financial securities. The best quantitative finance brings real insight into the relation between value and uncertainty, and it approaches the quality of real science; the worst is a pseudoscientific hodgepodge of complex mathematics used with obscure justification.

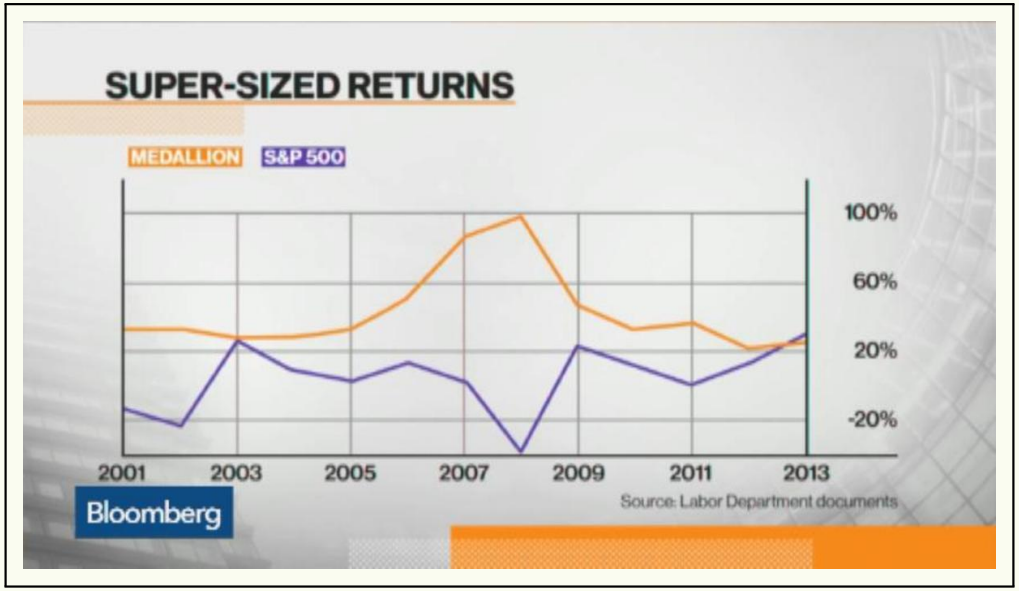


Picture source: Emanuel Derman's Blog

Quantitative Finance Cycle



Mathematical Models and Making Money



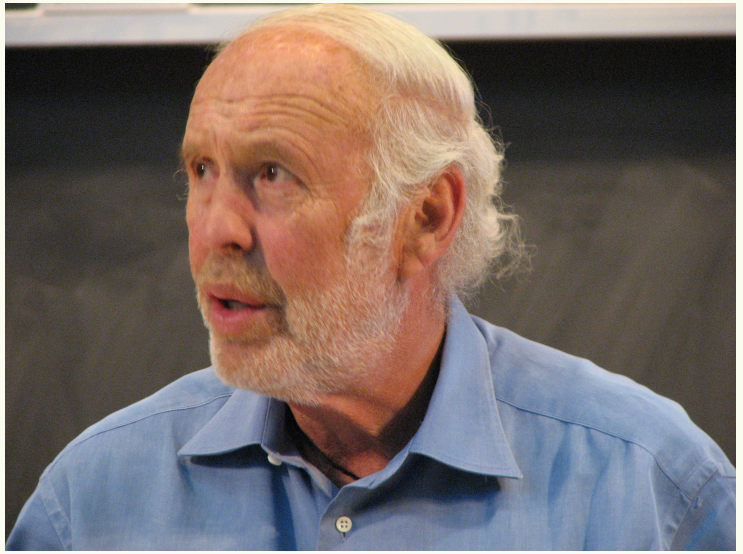
We began to bring in some mathematicians and scientists and built models. And then more people came in and we built more models. Then the business got better and better, and over the years, we have been enormously successful and made a ton of money—I have to confess.

James Simons

Why Quantitative? "THE wave of the future."

Now, a lot has happened since Sputnik went up and the days of the National Defense Education Act. The world's whole economic engine now is not just defense, but increasingly based on math and science. You know, from Genentech to Google to Goldman (Sachs), math & science is becoming king. . . .
Now, there at Goldman Sachs, these scientific types are called "**quants**," and some of you may have heard of quants, but at Google, they're just called employees, because they're all quants. . . .
And that's a wave of the future. **I think it's THE wave of the future**.

James Simons



Picture source: Wikipedia

Career, Career, and Career

- ♣ Quantitative researcher/analyst/strategist
- ♣ Quantitative risk analyst/manager
- ♣ Quantitative developer
- ♣ Quantitative associate (sales, trading, consultancy, etc)
- ♣ Samples of Career Sites
  - linkedin
  - efinancialcareers
  - indeed
  - recruit.net
  - Jobs.com.sg

Advice from Wall Street Executives

- Where do you think the largest job growth is within the quantitative finance industry?
  - Traders
  - Analysts (of risks especially)
- Top 5 credentials for a quantitative position?
  1. Strong Communications Skills
  2. STRONG MATHEMATICS
  3. STRONG PROGRAMMING SKILLS
  4. Ability to think out-side the box type of mentality.
  5. Good interpersonal skills.

  Good communication, passion, knowledge and skills (not only in programming or mathematics, but also some other areas), imagination (think about using different method to find the solution), and the most important thing is that he really likes math, programming and this job.

Inspiration

- Aced 31 alpha's in Cambridge's Mathematical Tripos
- 1973 **Senior Wrangler**: "the greatest intellectual achievement attainable in Britain"
- What his former tutor, **Béla Bollobás**, said of him:
  "... he was truly outstanding: he was head and shoulders above the rest of the students. He was not only the first, but the gap between him and the man who came second was huge."
  "... (he) was not only hardworking, conscientious and professional, but he was also very inventive. All the signs indicated that he would have been a world-class research mathematician."

  http://www2.ims.nus.edu.sg/imprints/interviews/BelaBollobas.pdf
- Written a sudoku solver in C++ for fun
- Who is this would-be "perfect" quant for Wall Street?

Polytechnic Mathematics

- Sets & Venn Diagrams
- Functions
- Quadratic & Cubic Equations
- Inequalities
- Binomial Theorem
- Sequences & Series
- Partial Fractions
- Mathematical Induction
- Trigonometry
- Complex Numbers
- Differentiation
- Integration

A-Level Math

1. Function and graphs
2. Calculus
3. Probability
4. Binomial and normal distributions
5. Sampling and hypothesis testing
6. Correlation and Regression

A great web site to revise your math: **A-level Maths Tutor**

International Baccalaureate Diploma Mathematics

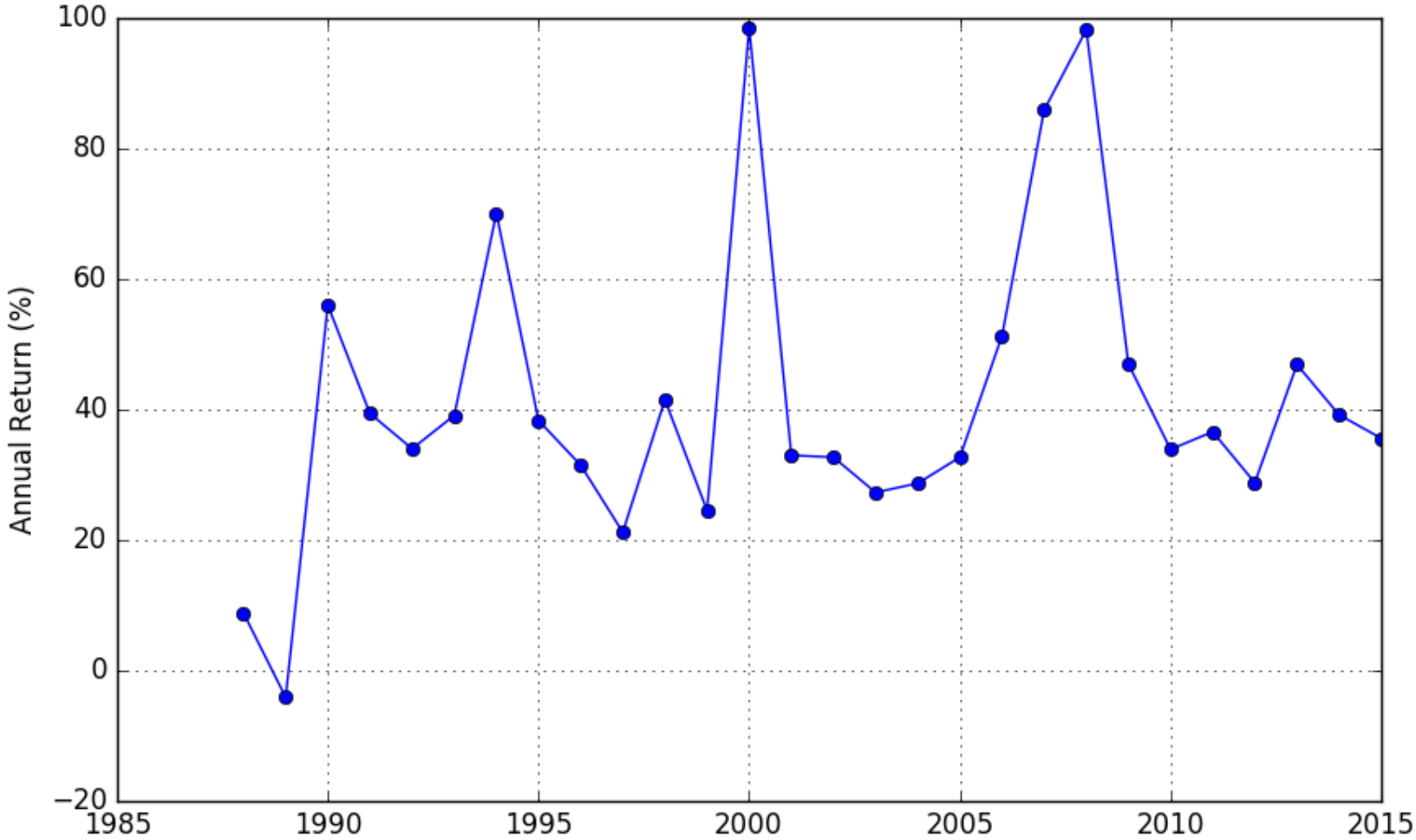
1. Algebra
2. Functions and equations
3. Circular functions and trigonometry
4. Vectors
5. Statistics and probability
6. Calculus
7. Mathematical exploration

A-Level List of Formulas

- Algebraic series: Binomial expansion, Maclaurin's expansion
- Partial fractions decomposition: Non-repeated and repeated linear factors, Non-repeated quadratic factor
- Trigonometry
- Derivatives
- Integrals
- Vectors
- Numerical Methods: Improved Euler's Method
- Standard discrete distributions: Binomial, Poisson
- Standard continuous distributions: Normal, Student's t
- Sampling and testing
- Regression and correlation

Pre-U Math App 1

- What is the probability of achieving Medallion's performances?

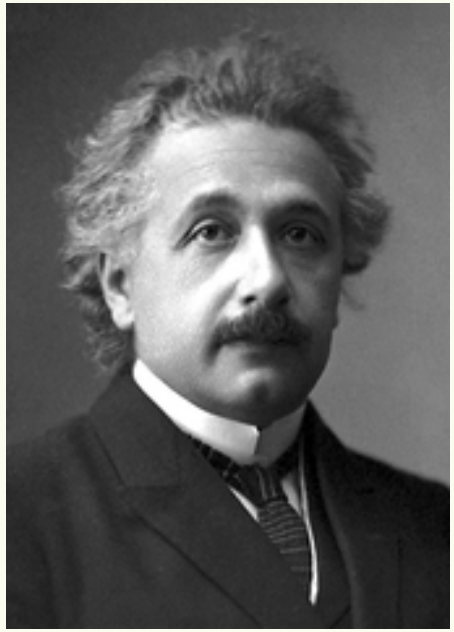


Pre-U Math App 2

- Ten ℚF students employed by different banks are getting together. They are all interested to know the average annual salary of the ℚF cohort. But every ℚF graduate does not want to disclose his or her salary to the other ℚF graduates, including you.
- Having learned "Creative Thinking," how would you solve this problem?
- Class Activity: Average GPA

Motivational?

Do not worry about your difficulties in mathematics. I can assure you mine are still greater.



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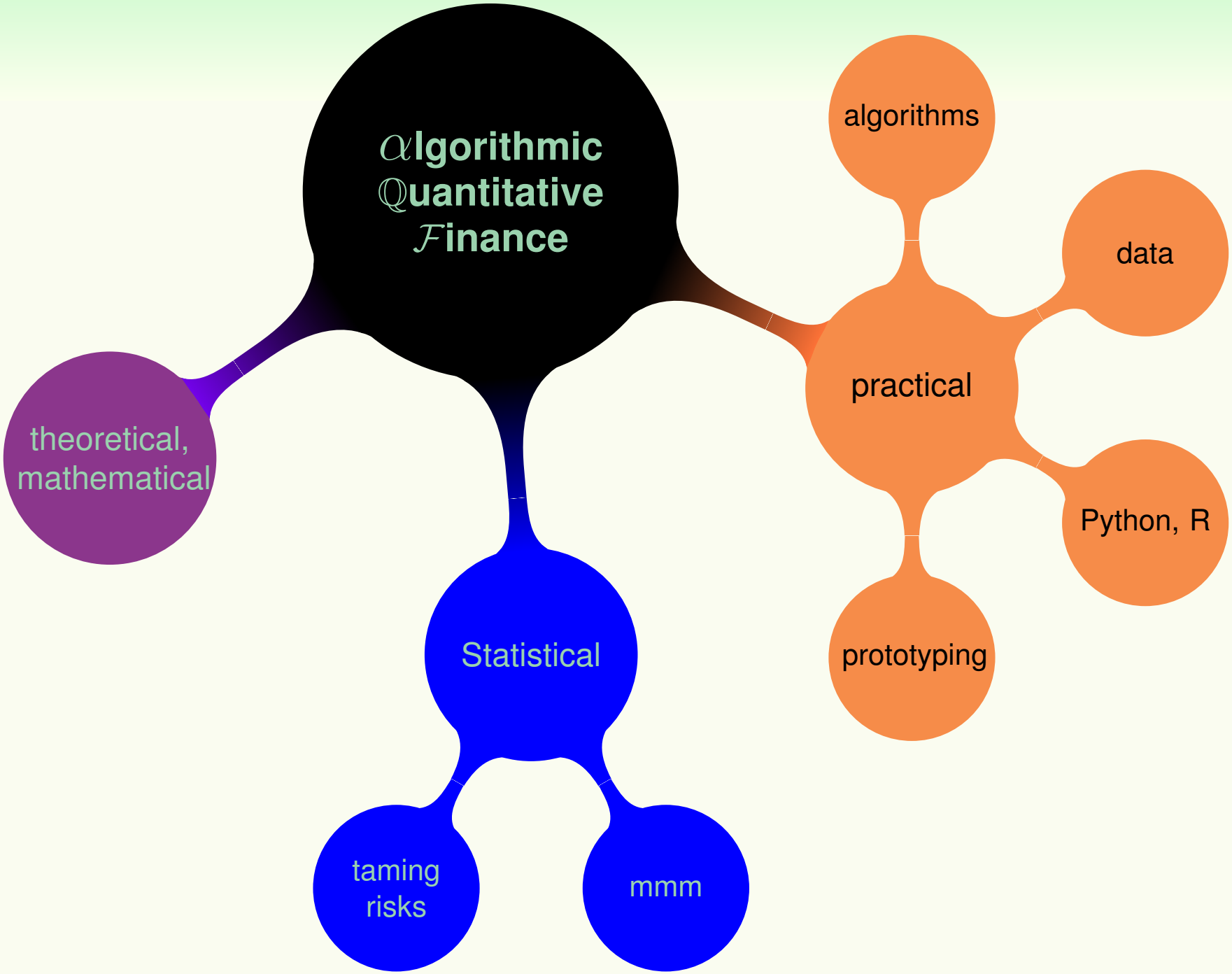
𝒜lgorithmic
ℚuantitative
ℱinance
theoretical, mathematical
Statistical
taming risks
mmm
practical
algorithms
data
Python, R
prototyping

Takeaways

1. ℚuantitative Finance in theory and in practice
2. A taste of problem (interview question) solving
3. A recap of pre-university math through tutorials
   - Medallion fund's performance
   - Average GPA
   - The life of Pi
4. Quants' way of thinking: Capability to **make educated guess correctly**, in un-encountered situation of ambiguity, uncertainty, and confusion.