

Quantitative Trading Guide

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Part 1: Background

1.1 What is Quantitative Trading?

Quantitative trading implements quantitative analysis in designing automated systems for the purpose of trading. Most quantitative trading requires a background in mathematics, economics, and/or computer science. The scarcity of students properly educated in these fields is reflected in the starting salaries at these firms – it is common for a first-year trader to make low six figures in total compensation. Another explanation for these large compensation packages could be the profitability of these firms. The Forbes 400 (2020) clearly shows how successful trading can be:

Rank	Name	Source
1	Jeff Bezos	Trading at D.E. Shaw, Founder of Amazon
4	Warren Buffett	Trading
14	Michael Bloomberg	General Partner at Salomon Brothers, Bloomberg LP
23	Jim Simons	Renaissance Technologies
26	Thomas Peterffy	Interactive Brokers
29	Ray Dalio	Bridgewater Associates
34	Ken Griffin	Citadel
36	Steve Cohen	Point72 Asset Management
39	Carl Icahn	Trading
56	George Soros	Trading
74	Israel Englander	Millennium Management
95	John Overdeck	Two Sigma Investments
95	David Shaw	Founder of D.E. Shaw
95	David Siegal	Two Sigma Investments
Etc.		

There are many different jobs that can be labelled under the umbrella of quantitative trading. For the purpose of this quantitative trading guide, we can further define high frequency traders and market makers.

A high frequency trader is usually focused on arbitrage and extremely fast trade execution. They can use mathematics to find statistically significant opportunities, or they can try to use their speed to take advantage of identical/similar securities trading at different prices across different exchanges.

A market maker usually provides a service (liquidity) by buying and selling securities using their own account. They continuously quote a bid (price they are willing to buy) and ask (price they are willing to sell) through an exchange's trading system. A market maker's bid is always below their ask, with the hope that they can continually buy at their bid and sell at their ask to capture a profit known as the bid-ask spread.

Another important distinction is between buy side and sell side firms. Buy side firms trade large portions of securities for the purpose of money management, while sell side firms deal with the creation, promotion, and selling of securities.

1.2 A List of Trading Companies

Over the past four years I have put together a list of trading companies operating in the United States. Most of these firms have similar job requirements and a similar interview process:

- 3Red
- 4170 Trading
- Acadian Asset Management
- Akuna
- Allston Trading
- AlphaSimplex
- AQR
- Arrow Street Capital
- Avatar Securities
- Belvedere Trading
- BlackEdge
- BlackRock
- Bluefin Trading
- BP Integrated Supply & Trading
- Bracebridge
- Brendan E. Cryan Group
- Bridgewater
- Brownstone
- Capula Investment Management
- Chicago Trading Company
- Citadel
- Citigroup Markets Analyst
- Consolidated Trading
- Cutler Group
- D.E. Shaw
- Dexterity Capital
- Domeyard
- DRW
- DV Trading
- Eagle Market Makers
- Eagle Seven
- Edgehog Trading
- Emergent Trading
- FinCad
- First Quadrant
- Five Rings
- Flow Traders
- Geneva Trading
- Geode
- Goldman Sachs
- Grace Hall Trading
- Graham Capital Management
- Group One Trading
- GSA Capital
- GTS
- Guggenheim
- HAP Capital
- Hard Eight Trading
- HC Tech
- Headlands Tech
- Hehmeyer
- Hudson River Trading
- ICY Capital
- IMC Trading
- Jane Street
- JP Morgan
- Jump Trading
- Key Bank
- Loomis Sayles
- Magnetar Capital
- Marquette Partners
- Marshall Wace
- Morgan Stanley
- Old Mission Capital
- Optiver
- PanAgora
- PDT Partners
- Peak6
- PIMCO
- Point72
- Polaris7
- Prime Trading
- QuantLab
- Quantres
- Radix Trading
- RBC Global Markets
- Renaissance Technologies
- Sartre Group
- Schonfeld
- Simplex Investments
- SMB Capital
- Societe Generale
- Square Point Capital
- State Street
- Stevens Capital Management
- Susquehanna
- Teza
- Tibra
- Tower Research
- Tradebot
- Transmarket
- Tudor Investments
- TwoSigma
- UBS
- Valkyrie
- Vatic Labs
- Vector Trading
- Virtu
- Volant Trading
- Weiss Asset Management
- Wells Fargo
- Western Asset
- WHTrading
- Wintermute Trading
- Wolverine
- XR Trading
- XTX Markets

1.3 Trading Competitions

Perhaps one of the best places to learn about a career in trading is at a trading competition. For university students, these competitions present an opportunity to meet with representatives from trading firms. For trading firms, these competitions conveniently gather qualified candidates for internships and full-time opportunities in one place. Not all the following competitions are in person, but success in these competitions will look good on a resume:

- ThinkOrSwim Trading Challenge
- Citadel Data Open
- Princeton Quant Trading Conference
- CME Group University Trading Challenge
- Traders at MIT
- Rotman International Trading Competition
- University of Chicago Midwest Trading Competition
- WorldQuant Challenge

Part 2: Qualifications

2.1 Recommended Coursework

The following coursework is recommended for students who aspire to a career in quantitative trading:

- Mathematics
 - Calculus
 - Matrix Algebra
 - Differential Equations
 - Probability and Statistics
 - Logic and Discrete Mathematics
 - Financial Mathematics
 - Optimization
 - Operations Research
 - Linear Statistical Models
 - Time Series Analysis
- Computer Science
 - Object-Oriented Software Development
 - Analysis of Algorithms
 - Parallel and Concurrent Programming
 - Machine Learning
 - Artificial Intelligence
 - Data Mining
- Finance
 - Options, Futures, and Derivative Securities
 - Quantitative Risk Management
 - Investments
 - Capital Markets
 - Financial Accounting
- Economics
 - Microeconomics
 - Macroeconomics
 - Econometrics

2.2 Extracurriculars / Projects

Most applicants for a quant trading position will be involved in research outside of class. Firms look for applications that, in addition to the job requirements, include activities not related to quantitative trading. This may be a sport, club, or hobby that shows you have a life outside of work. Overall, be sure to have one or more of the following on your resume:

- Research Reports: Published research and/or Individual research
- Team Project: Your own code repository with several individual programming projects as well as a few team programming projects, all with multiple commits
- Entrepreneurial Spirit: Start a small company or side hustle

- Trading Experience: Create a trading algorithm that connects to a Brokerage API and trades a practice account (or better yet, a real one)
- Trading Club: Joining and/or starting a club relating to quantitative trading
- Something Unique: A sport, club, or hobby that you are involved with and has nothing to do with quantitative trading

While these projects are not simple, I can assure you that they will quickly set you apart from other applicants.

2.3 Books

The most effective way to learn all the required material is to **read the following material and take notes**. These books are commonly used as textbooks for the above coursework and some are even considered recommended/required readings by certain trading firms. While it is not necessary to know all this material, I can almost guarantee you will have an interview question from one of these books.

- Trading Interview Questions
 - A Practical Guide to Quantitative Finance Interviews (Zhou)
 - Heard on the Street (Crack)
- Linear Models
 - Intro to Linear Regression Analysis (Montgomery, Peck, Vining)
 - Applied Linear Statistical Models (Kutner, Nachtsheim, Neter, Li)
 - Applied Linear Regression Models (Kutner)
 - Linear Models with R (Faraway)
- Probability:
 - A First Course in Probability (Ross)
 - A Second Course in Probability (Ross)
 - Probability, Random Variables and Stochastic Processes (Papoulis, Pillai)
 - Probability and Random Processes (Gubner)
 - Time Series Analysis (Hamilton)
 - Time Series Analysis and its Applications (Shumway, Stoffer)
- Computer Science
 - Pro Git (Chacon, Straub)
 - The Linux Command Line (Shotts)
 - Python Data Science Handbook (VanderPlas)
 - Python for Data Analysis (McKinney)
 - Python Tutorial (Rossum)
 - Introduction to Algorithms (Cormen)
 - Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow (Geron)
 - Go Programming Language (Donovan, Kernighan)
 - The C++ Programming Language (Stroustrup)
 - Principles and Practice using C++ (Stroustrup)
 - Advanced C and C++ Compiling (Stevanovic)
 - Java: The Complete Reference (Schildt)
 - The Java Language Specification (Gosling, Joy)
 - Cracking the Coding Interview (McDowell)

- Artificial Intelligence: A Modern Approach (Norvig, Russell)
- LaTeX: A Document Preparation System (Lamport)
- Learning from Data (Abu-Mostafa, Magdon-Ismail)
- Machine Learning and Big Data with kdb+/q (Novotny, Bilokan)
- q for Mortals V3: Intro to q programming (Borrer)
- MATLAB: A Practical Intro to Programming (Attaway)
- Numerical Analysis (Burden, Faires)
- R for Data Science (Wickham, Grolemund)
- Mathematics
 - Discrete Mathematics (Levin)
 - Elementary Linear Algebra (Larson)
 - Introduction to Linear Algebra (Strang)
 - Differential Equations and Linear Algebra (Strang)
 - Convex Optimization (Vandenberghe, Boyd)
 - Nonlinear Dynamics and Chaos (Strogatz)
- Economics
 - Game Theory: An Introduction (Tadelis)
- Financial Engineering
 - Options, Futures, and Other Derivatives (Hull)
 - Option Volatility and Pricing (Natenberg)
 - Quantitative Risk Management (McNeil, Frey)
 - The Volatility Smile (Derman, Emanuel)
 - The Volatility Surface (Gatheral)
 - Dynamic Hedging (Taleb)
 - Options Trading: The Hidden Reality (Cottle)
- Trading
 - Trading and Exchanges (Harris)
 - Volatility Trading (Sinclair)
 - High Frequency Trading (Aldridge)
- Other
 - Problem Solving through Problems (Larson)
 - Flash Boys (Lewis)
 - Liar's Poker (Lewis)
 - The Big Short (Lewis)
 - When Genius Failed (Lowenstein)

Part 3: The Interview Process

3.1 Types of Interview Questions

The types of questions that are most frequently asked are, in order of most to least frequent:

1. Mental Math
 - a. Two-digit multiplication:
 - $63 * 79$
 - b. Division:
 - Round $17/45$ to two decimals
 - c. Exponents
 - 7^4
 - d. Percentages
 - 15% of 180
 - e. Square Roots
 - $\sqrt{2}$ to two decimals
2. Math Competition Problems
 - a. Word problems
 - What is the probability that the sum of two dice is 8?
 - A stick is broken into three pieces, what is the probability that they form a triangle?
3. Series and Sequences
 - a. What number comes next in the sequence?
 - 1,2,4,5,7,8,10,11,13, ...
 - b. What is the sum of integers 1 to x?
 - $1 + 2 + \dots + x$
 - c. What is the sum of the squared integers from 1 to x?
 - $1^2 + 2^2 + \dots + x^2$
4. Market Making and Betting
 - a. Make me a market (provide a bid/ask) on the population of New York
5. Word Association
 - a. X is to Y as Z is to ____
 - b. Read the story and answer questions
6. Reading Comprehension
 - a. Read the following text and answer a few questions

3.2 Preparation

In order to prepare for these interviews:

1. Practice on mental math websites
 - <https://arithmetic.zetamac.com/>
 - <http://tradermaths.com/>
 - <https://graduatetrader.com/>

2. Read books geared specifically towards quantitative trading interviews
 - A Practical Guide to Quantitative Finance Interviews (Zhou)
 - Heard on the Street (Crack)
3. Research the trading firm that you are interviewing for
4. Come up with questions for the interviewer
5. Practice describing each item in your resume, and why you see it helping you in trading
6. Answer behavioral questions in the S.T.A.R. format
 - Situation: What was the situation you were in?
 - Task: What is the task you were supposed to accomplish?
 - Action: What action did you take to accomplish that task?
 - Result: What was the result of your action?
7. Make sure to schedule interviews so that you have additional time beforehand for practice and additional time after in case the interview goes for longer than expected

3.3 Interview Timeline

The online test is typically the first round of the interview process. When an applicant applies, their resume may or may not be pre-screened, and then they an email that goes along these lines:

Dear Applicant,

Your application to ___ Trading has been received, and we would like to offer you a chance to take our timed online assessment. The assessment will be available for 24 hours, and once you begin you will have one hour to complete it. When you are ready, click the below link to begin:

<http://<Link>.com>

Thanks,

Recruiter

___ Trading

If you pass your online assessment, you will usually receive an email like this from your recruiter:

Dear Applicant,

Thank you for completing our online assessment. After reviewing your results, I would like to schedule a phone interview with you! Please schedule a time that works at the following link:

<http://<Link>.com>

Thanks,

Recruiter

___ *Trading*

Before scheduling your interview, remember to **use the right time zone!** After passing the behavioral rounds, you will get an email like this:

Dear Applicant,

I enjoyed speaking with a few days ago! I would like to invite you to speak with one of our full-time traders. Please schedule a time that works at the following link:

<http://<Link>.com>

Thanks,

Recruiter

___ *Trading*

Interviews with traders will have the same general format as before, but now you will only briefly discuss behavioral questions while the bulk of the interview will be technical questions. The trader will likely have had a similar background as you, so be prepared to answer in-depth technical questions about classes you've taken or projects you've done. If possible, also ask your interviewer for their email so they can answer any questions you have later. After the interview, feel free to send an email to your interviewer thanking them for their time. If you pass the phone interviews, you will get an email like this:

Dear Applicant,

Congratulations! We enjoyed speaking with you, and we would like to invite you to our final round on ___/___/___ from ___:___ CST to ___:___ CST. Please reply to me confirming that you are available to participate!

Thanks,

Recruiter

___ Trading

The Superday will typically consist of multiple hour-long interviews, each with a different trader and/or recruiter. Consider the Superday a collection of behavioral and technical interviews. Make sure to prepare as much as possible, dress as nicely as possible, and get a good night's sleep before the interview.