Carnegie Mellon University
Master of Science in Computational Finance

MSCF

2021 CAREERS GUIDE

QUANTITATIVE FINANCE AND FINANCIAL ENGINEERING

TOP CAREERS IN FINANCIAL ENGINEERING

An inside look at the industry demand, rewarding challenges and unique benefits of a career in financial engineering

"Financial engineering", also known as "quantitative finance", is the application of math, statistics and coding to meet the challenges of today's financial markets.
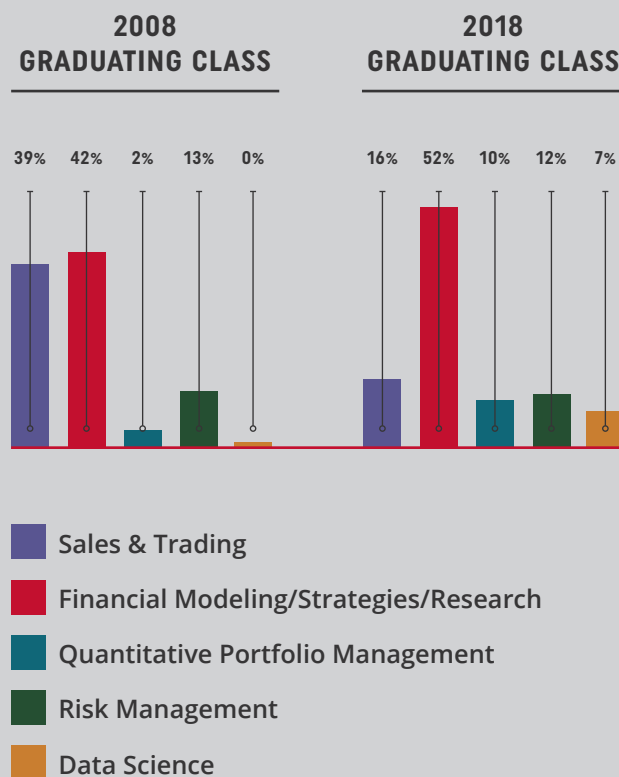
Before diving into the different jobs, required skill sets and impressive salaries in this field, it's important to understand the state of the financial industry and the vital role played by "financial engineers."

Over the last 25 years, the finance industry has undergone a fundamental transformation. Beginning in the 1990s, deregulation and technological advancements resulted in a proliferation of competing markets and reduced execution costs while extensive regulation implemented after the 2008 financial crisis now requires firms to better measure and control risk in their portfolios. In addition, the increased granularity and volume of data available for financial decision-making has created new opportunities for technology-savvy quants to lend and manage money.

To prosper in this new environment, bankers, traders and money managers must understand the probabilistic distributions driving economic forecasts, be able to manage and analyze large financial data sets to build trading, investment and risk models and understand the proper use and limitations of the mathematical models on which much financial decision-making is based. The industry looks to financial engineers for the knowledge and training to perform these functions.
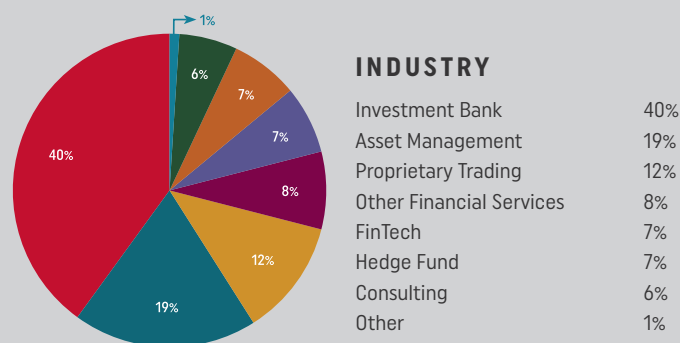
WHERE THE QUANTS GO

Graduates from Carnegie Mellon's Master of Science in Computational Finance (MSCF) program are taking different career paths since the 2008 financial crisis.

2008 GRADUATING CLASS						2018 GRADUATING CLASS				
39%	42%	2%	13%	0%		16%	52%	10%	12%	7%

- ■ Sales & Trading
- ■ Financial Modeling/Strategies/Research
- ■ Quantitative Portfolio Management
- ■ Risk Management
- ■ Data Science

2008 does not include Other career paths (4%)
2018 does not include Consulting and Other career paths (3%)

INDUSTRY

Investment Bank	40%
Asset Management	19%
Proprietary Trading	12%
Other Financial Services	8%
FinTech	7%
Hedge Fund	7%
Consulting	6%
Other	1%

Source: Richard Bryant, Executive Director of MSCF at Carnegie Mellon University

These financial engineers, or "quants," have different responsibilities depending on their positions. Financial engineers who work directly with traders are referred to as "front office" quants, while those who research, create and validate new financial models are known as "middle office" quants.

The challenges of today's complex financial industry loom large, and the demand for both front and middle office quants is strong.

From proprietary trading and hedge funds to insurance companies, commodities firms and mutual funds, firms on the "buy-side" buy securities and services to generate returns. Multinational investment banks, the "sell-side," sell securities, research, their expertise and distribution networks to the buy-side.

Sell-side jobs are mostly located in New York, Hong Kong and London. While the buy-side is not nearly so geographically centered, many money management and trading opportunities can be found in New York, Chicago, San Francisco, Philadelphia and Boston.

If you are interested in banking and finance and have a strong background in mathematics and statistics, a career in quantitative finance could be the perfect fit.

THERE ARE FIVE PRIMARY QUANTITATIVE FINANCE CAREER PATHS:

- Sales and Trading
- Financial Modeling/Strategies/Research
- Quantitative Portfolio Management
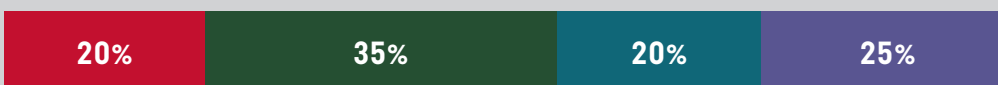- Risk Management
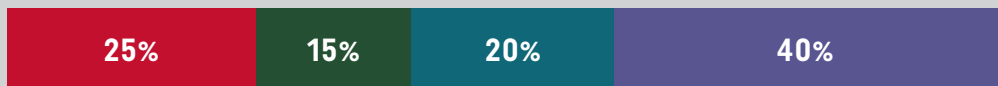- Data Science

SALES AND TRADING

SKILLS REQUIRED:

30%	10%	30%	30%

OTHER CAREER PATH SKILLS:

FINANCIAL MODELING/STRATEGIES/RESEARCH

20%	35%	20%	25%

QUANTITATIVE PORTFOLIO MANAGEMENT

20%	20%	30%	30%

RISK MANAGEMENT

25%	15%	20%	40%

DATA SCIENCE

40%	10%	10%	40%

Legend: DATA ANALYTICS/PROGRAMMING — MATHEMATICS — FINANCE/ECONOMETRICS — STATISTICS
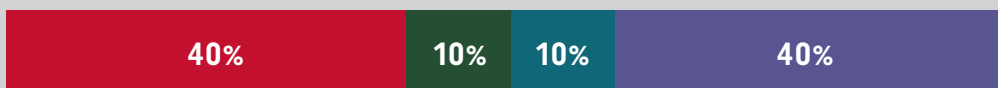
Careers in sales and trading take many forms.

If you are trained in quantitative finance and working in a sell-side sales role, you will be managing client relationships where sophisticated derivative products are under consideration or whose performance is being evaluated. Trading will likely involve market-making or managing high-frequency and other algorithmic positions.

As a market maker, your goal is to profit on the bid-ask spread, taking positions only as inventory. While these roles often do not require the formidable statistics and computer science skills required of the high-frequency and algorithmic traders, you will need to have a good grasp of quantitative disciplines and risk management.

High frequency and algorithmic traders generally seek to profit from small price discrepancies or expected reoccurring relative price relationships. This form of quantitative trading requires high levels of data and market structure analysis for which strong math, statistics and computer science skills are essential.

In addition to strong technical skills, you will need to pay close attention to detail, possess strong communication skills and be knowledgeable of the ever-changing regulations of the industry. Base compensation is generally lower in this area with annual bonuses often well in excess of the base.

"Quantitative trading is a complex and interesting area of quantitative finance. Before applying for quantitative trading jobs, it is necessary to carry out a significant amount of groundwork study. At the very least, you will need an extensive background in statistics and econometrics, with a lot of experience in implementation via a programming language."
– Michael Halls-Moore, founder of QuantStart

"This field is becoming more competitive every day. While technical knowledge is important, it's not the only thing that is necessary. People have to come in with some business sense. They should understand how the markets work, listen to market commentary and develop a market sense."
– Akram Ayyash, VP at BNP Paribas

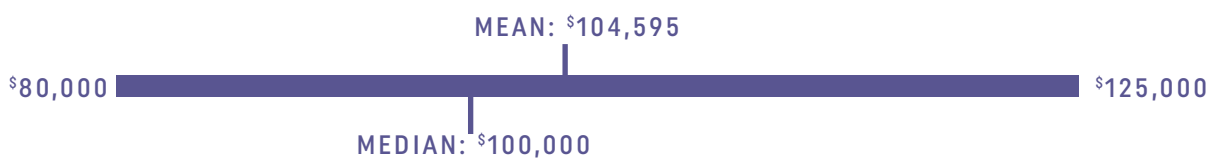## ENTRY-LEVEL TRADING TITLES INCLUDE:

- **Assistant Trader**
- **Junior Trader**
- **Options Trader**
- **Proprietary Trader**
- **Quantitative Trader**
- **Quantitative Trading Analyst**
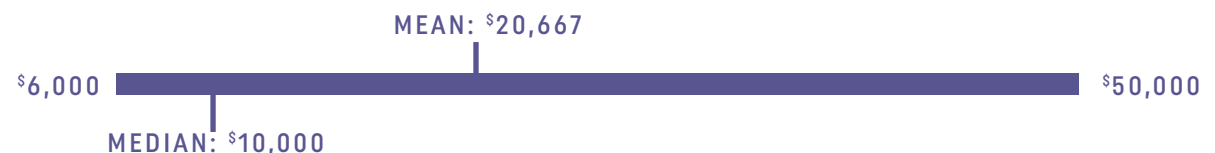- **Rates Trading Associate**
- **Sales and Trading Analyst**

SALARY RANGE*

* Without bonuses

MEAN: $104,595
$80,000 — $125,000
MEDIAN: $100,000

64% RECEIVE SIGNING BONUSES

MEAN: $20,667
$6,000 — $50,000
MEDIAN: $10,000

FINANCIAL MODELING/STRATEGIES/RESEARCH

SKILLS REQUIRED:

DATA ANALYTICS/PROGRAMMING	MATHEMATICS	FINANCE/ECONOMETRICS	STATISTICS
20%	35%	20%	25%

OTHER CAREER PATH SKILLS:

	DATA ANALYTICS/PROGRAMMING	MATHEMATICS	FINANCE/ECONOMETRICS	STATISTICS
SALES AND TRADING	30%	10%	30%	30%
QUANTITATIVE PORTFOLIO MANAGEMENT	20%	20%	30%	30%
RISK MANAGEMENT	25%	15%	20%	40%
DATA SCIENCE	40%	10%	10%	40%

Legend:
- **DATA ANALYTICS/PROGRAMMING**
- **MATHEMATICS**
- **FINANCE/ECONOMETRICS**
- **STATISTICS**

Positions along this career path encompass a variety of tasks, including pricing exotic derivatives, commodities and structured products, building risk and optimal execution models, forecasting economic trends and generating quantitative trading and investment ideas for clients.

The successful modeler, "strat" or researcher, must possess strong math, statistics, coding and communication skills. Other capabilities required for this career path include the ability to parse large data sets, comprehend the technical aspects of financial model building, understand the implications of corporate structure and have a rudimentary knowledge of corporate accounting.

Jobs in financial modeling, strategies and research are found at sell-side banks, buy-side money managers and the regulators. As a front office quant, you will be involved with structuring, pricing and developing trading tools; as a middle office quant, you will validate the trading and pricing models developed by the front office.

In addition to pricing structured products and derivatives, you may have the opportunity to work with a variety of clients. From private banks and hedge funds to asset managers and corporations, you will view the same trade from different perspectives and develop an understanding of how others see the market, consider products and evaluate pricing.

Successful practitioners along this career path enjoy developing creative solutions to challenging problems using a variety of models and applications.

*"Due to the challenging nature of the work -
a blend of mathematics, finance and computer
skills – quants are in great demand and able to
command high salaries."*
– Tristan Yates, Investopedia writer

*"This role satisfies my hunger of doing analytical
work and also provides an opportunity to
work with clients. I enjoy the balance between
building models, coming up with trading
strategies, publishing research and interacting
with a wide gamut of clients."*
*– Devdeep Sarkar, Vice President - FICC
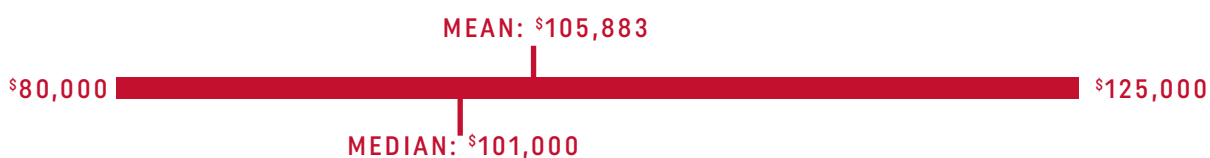Systematic Trading Strategies at Goldman Sachs*

ENTRY-LEVEL FINANCIAL MODELING/ STRATEGIES/RESEARCH TITLES INCLUDE:

- **Associate, Quantitative Analytics**
- **Corporate Treasury Strategist**
- **Credit Structuring Analyst**
- **Derivatives Analyst**
- **Financial Technology Associate**
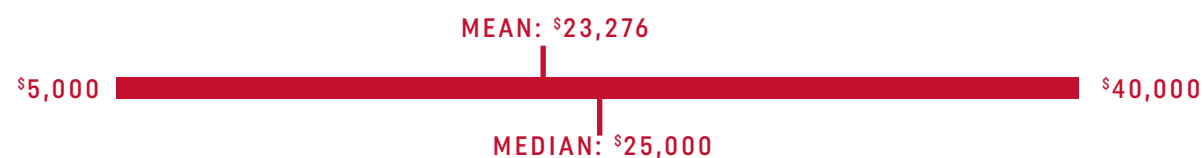- **Quantitative Strategist**
- **Trading Strategist**
- **Fixed Income Strategist**

SALARY RANGE*

* Without bonuses

MEAN: $105,883

$80,000 ———————————————— $125,000

MEDIAN: $101,000

64% RECEIVE SIGNING BONUSES

MEAN: $23,276

$5,000 ———————————————— $40,000

MEDIAN: $25,000

QUANTITATIVE PORTFOLIO MANAGEMENT

SKILLS REQUIRED:

20%	20%	30%	30%

OTHER CAREER PATH SKILLS:

SALES AND TRADING

30%	10%	30%	30%

FINANCIAL MODELING/ STRATEGIES/RESEARCH

20%	35%	20%	25%

RISK MANAGEMENT

25%	15%	20%	40%

DATA SCIENCE

40%	10%	10%	40%

Legend: DATA ANALYTICS/PROGRAMMING — MATHEMATICS — FINANCE/ECONOMETRICS — STATISTICS

Quants working in portfolio management manage the money of others (e.g., pension funds, retail investors, insurance companies) using quantitative models, generally analyzing large historical data sets for small opportunities that can be leveraged across a large group of securities. Quantitative portfolio managers also develop fast algorithms to trade on market news.

Quantitative portfolio management is unlike analysis performed by the "fundamental" money managers who seek positive returns by scrutinizing the financial statements of a company or an industrial sector to predict profitability and generally invest over longer-term horizons.

You may be expected to create investment strategies using statistical methods and technology to process vast data sets in order to find predictive patterns in historical prices or asked to use mathematical models to identify and exploit misaligned prices among related securities.

Coding skills are also important. Given the large number of trades executed, an important aspect of portfolio management involves the efficiency of execution. Models for determining "optimal execution" (the best trading venues, the speed of execution and strategies for moving large blocks of securities without major movements in price) are all part of the job as a portfolio manager.

"Trends in hiring are shifting away from banking and more towards boutique buy-side firms. With more specialized needs, these firms are looking for candidates that have both the hard skills to succeed and relevant exposure to the problems confronting today's investment community."
– Michelle Ruvolo, Executive Director at J.P. Morgan Alternative Asset Management

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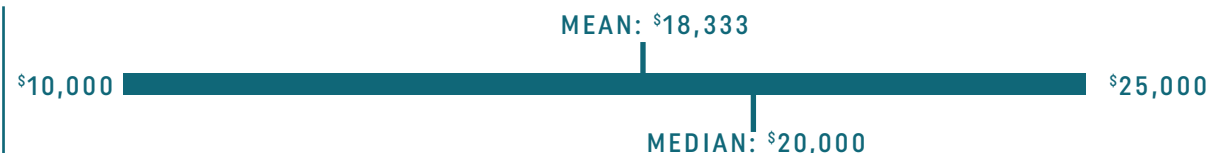## ENTRY-LEVEL PORTFOLIO MANAGEMENT TITLES INCLUDE:

- **Portfolio Management Analyst**
- **Quantitative Research Associate**
- **Research Analyst**
- **Investment Analyst**
- **Quantitative Analyst**

SALARY RANGE*

* Without bonuses

MEAN: $115,944
$100,000 ———————————————— $125,000
MEDIAN: $108,000

33% RECEIVE SIGNING BONUSES

MEAN: $18,333
$10,000 ———————————————— $25,000
MEDIAN: $20,000

RISK MANAGEMENT

SKILLS REQUIRED:

25%	15%	20%	40%

OTHER CAREER PATH SKILLS:

SALES AND TRADING

30%	10%	30%	30%

FINANCIAL MODELING/STRATEGIES/RESEARCH

20%	35%	20%	25%

QUANTITATIVE PORTFOLIO MANAGEMENT

20%	20%	30%	30%

DATA SCIENCE

40%	10%	10%	40%

■ DATA ANALYTICS/PROGRAMMING ■ MATHEMATICS ■ FINANCE/ECONOMETRICS ■ STATISTICS

The science (and art) of computing and managing the credit and market risk borne by traders and portfolio managers has grown in complexity and importance since the financial crisis of 2008 and is in great demand by financial firms and the regulators. This increased appreciation has resulted in positions offering more authority, compensation and prestige.

As a risk manager, you will need to identify, assess and prioritize risk. Your responsibilities may include reviewing trading models, developing bank stress tests, setting position limits and sector exposures, evaluating liquidity ratios and establishing regulatory capital levels.

You will need to be familiar with the regulations and mandates that impact the financial industry. For example, the Dodd-Frank Act requires banks to compute a credit valuation adjustment (CVA) for each of their trades. CVA considers the risk of counterparty default and the potential loss in the event of a default. CVA must be recomputed on a regular basis for the entire portfolio, a massive undertaking for a firm holding hundreds of thousands of long-lived deals. Most importantly, the bank must set aside expensive risk capital against observed CVA fluctuations.

Regulatory capital issues, liquidity buffers, funding restrictions, how and when to quantify the riskiness of loans and the probability of default are all areas where the banks are under scrutiny. Successful hedge funds must also carefully manage the risks their traders and portfolio managers are taking on.
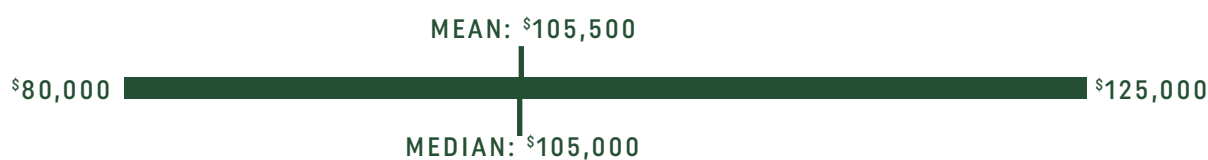
"Managers want people who understand risk before they move into fixed income portfolio management and derivatives trading. It's good to have risk management as a foundation even if you don't do it in the long run."
– Daryl Hershberger, Treasurer at TIAA-CREF

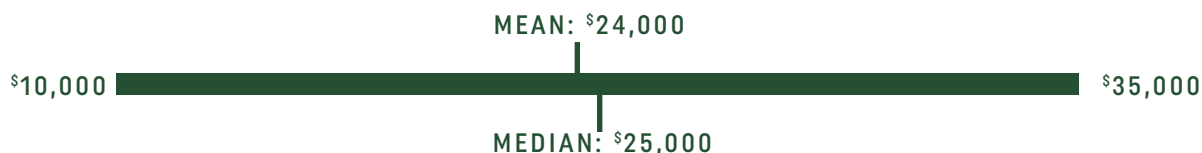## ENTRY-LEVEL RISK MANAGEMENT TITLES INCLUDE:

- **AVP, Franchise Risk Architecture**
- **Associate, Treasury Risk**
- **Investment Risk Analyst**
- **Market Risk Analyst**
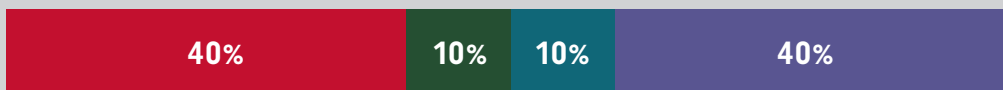- **AVP, Asset and Liability Management**

SALARY RANGE*

* *Without bonuses*

MEAN: $105,500
$80,000 ——————————————— $125,000
MEDIAN: $105,000

50% RECEIVE SIGNING BONUSES

MEAN: $24,000
$10,000 ——————————————— $35,000
MEDIAN: $25,000

DATA SCIENCE

SKILLS REQUIRED:

40%	10%	10%	40%

OTHER CAREER PATH SKILLS:

SALES AND TRADING

30%	10%	30%	30%

FINANCIAL MODELING/
STRATEGIES/RESEARCH

20%	35%	20%	25%

QUANTITATIVE PORTFOLIO
MANAGEMENT

20%	20%	30%	30%

RISK MANAGEMENT

25%	15%	20%	40%

- **DATA ANALYTICS/PROGRAMMING**
- **MATHEMATICS**
- **FINANCE/ECONOMETRICS**
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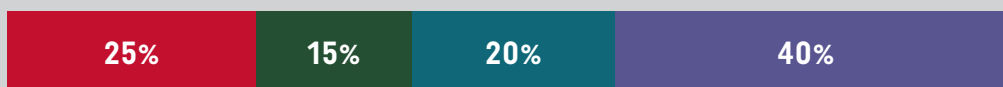
Data utilized in modern finance is no longer limited to simple market information and company financials. Firms work to gain an advantage by making use of data via twitter streams, news feeds, and other text-based information sources. Companies leverage satellite imagery to count cars in parking lots at stores and customer activity is mined to target new opportunities for financial products.

As a Data Scientist, you will apply a wide range of machine learning and data mining techniques including predictive modeling, natural language processing, and pattern recognition to answer complex questions in a quantitative manner. Firms are increasingly turning to Data Scientists to generate insights on the overwhelming amount of data they have at their disposal.

A career as a Data Scientist requires a deep understanding of both statistical and machine learning tools, and great facility in the standard software packages used in implementing these methods, primarily Python and R. Using unstructured data sets containing billions of entries, you will create automated systems that perform anomaly detection and data classification to process the data into usable structures. Thereafter, you may need to present the results of your analysis to portfolio managers and research analysts employing data visualization techniques.

"Applying advanced cloud computing technology to develop complex statistical models in the fast-paced financial markets is challenging, rewarding – and in incredibly high demand."
– Braxton McKenzie, Partner / Data Scientist at KCL Capital

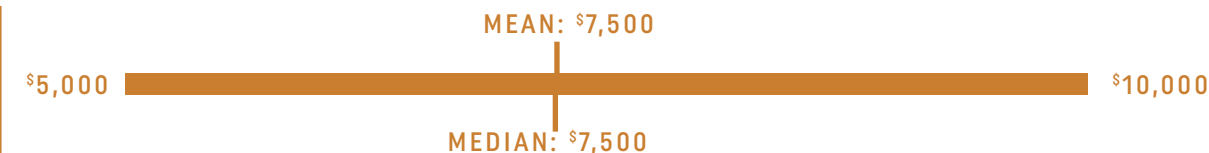## ENTRY-LEVEL TRADING TITLES INCLUDE:

- **Data Scientist**
- **Data Science Analyst/Associate**
- **Data/Business Analytics Analyst/ Associate/Consultant**

- **Financial Engineer**
- **Research Scientist/Associate**
- **Quant Analytics & Model Development**

SALARY RANGE*

* *Without bonuses*

MEAN: $107,500
$100,000 — $120,000
MEDIAN: $105,000

50% RECEIVE SIGNING BONUSES

MEAN: $7,500
$5,000 — $10,000
MEDIAN: $7,500

Positions in finance are intellectually challenging, critical to the economy and well compensated. While it is possible to enter the finance industry with a STEM (Science, Technology, Engineering and Mathematics) education at any level, many choose to enter after earning a master's degree in quantitative finance.

www.QuantNet.com is an excellent resource to learn more about the field of quantitative finance. Additionally, QuantNet describes thirty quantitative finance masters programs throughout North America. Admission to these programs will generally require a solid background in:

- **Multi-variable calculus**
- **Differential equations**
- **Linear algebra**
- **Calculus-based probability**
- **Statistical inference and data analysis**
- **Programming experience in an object-oriented language (e.g., C++)**
- **Good written and oral communication skills**
- **Ability to work as part of a team**
- **An interest in the financial markets**

Typical coursework in these programs includes stochastic calculus, term structure and linear models, optimization, programming, econometrics, time series, simulation and corporate finance.
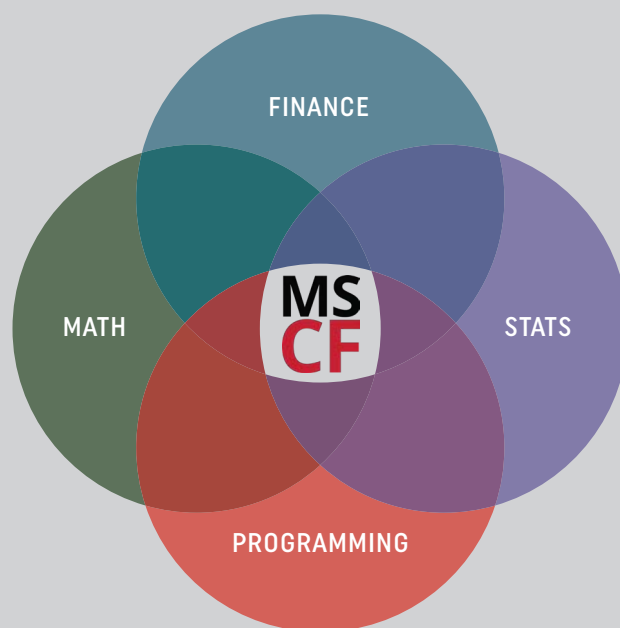
To compete globally, our economy needs an efficient and competitive financial system. The health of this system depends upon the talent of people like you – well-educated professionals with a background in mathematics, statistics and computer science – working in the field of quantitative finance.

MSCF
Master of Science in Computational Finance

SINCE 1994, CARNEGIE MELLON'S TOP-RANKED MASTER OF SCIENCE IN COMPUTATIONAL FINANCE PROGRAM HAS PREPARED STUDENTS FOR HIGHLY SUCCESSFUL QUANTITATIVE FINANCE CAREERS THROUGH A UNIQUE COMBINATION OF CUSTOMIZED CURRICULUM, PIONEERING FACULTY AND A FULL-SERVICE CAREER CENTER.

FINANCE

MATH

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PROGRAMMING

www.cmu.edu/mscf