# Syllabus

**PART 1**

[**Quantitative Trading**](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251)

Learn the basics of quantitative analysis, including data processing, trading signal generation, and portfolio management. Use Python to work with historical stock data, develop trading strategies, and construct a multi-factor model with optimization.

* + Project: [Trading with Momentum](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251/modules/ff0c8cc4-2cf0-4d10-b053-d4694d8c4ea3/lessons/19d4fe10-23f4-4347-9dfd-058c461cc7ef/project)
  + Project: [Breakout Strategy](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251/modules/f91e6d6f-1a0d-4f3c-a5ca-41e8750a38e8/lessons/acecae74-18c3-45c0-8b2d-5ed0f84029d4/project)
  + Project: [Smart Beta and Portfolio Optimization](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251/modules/8f3047b9-8592-4c29-aa80-3cfad73529cf/lessons/1fde82c8-9b3e-49ae-8073-20ed41fb2c50/project)
  + Project: [Multi-factor Model](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251/modules/1976c245-f4ec-42bf-9611-180753a3a4df/lessons/1c0d2c68-5c5f-4367-8604-5cc28d653568/project)

**Estimated time: 71 days**

**PART 2**

[**AI Algorithms in Trading**](https://classroom.udacity.com/nanodegrees/nd880/parts/20d53643-50e8-41b6-8063-3d2ac4934bb2)

Learn how to analyze alternative data and use machine learning to generate trading signals. Run a backtest to evaluate and combine top performing signals.

* + Project: [NLP on Financial Statements](https://classroom.udacity.com/nanodegrees/nd880/parts/20d53643-50e8-41b6-8063-3d2ac4934bb2/modules/355092e7-edc3-4a1b-aad8-022d1234c9c5/lessons/d1d781e4-916a-4d4d-b590-91db42ad8242/project)
  + Project: [Sentiment Analysis with Neural Networks](https://classroom.udacity.com/nanodegrees/nd880/parts/20d53643-50e8-41b6-8063-3d2ac4934bb2/modules/603e88cb-f190-4ede-84e7-055ce6f607c5/lessons/10057b09-9ff6-4681-b7d4-1ecec322a555/project)
  + Project: [Combining Signals for Enhanced Alpha](https://classroom.udacity.com/nanodegrees/nd880/parts/20d53643-50e8-41b6-8063-3d2ac4934bb2/modules/ef2dbe94-bc68-446f-8b3e-98ef1ccd776e/lessons/a97c8cae-bc8d-4626-9e11-adf65c500ab9/project)
  + Project: [Improve Your LinkedIn Profile](https://classroom.udacity.com/nanodegrees/nd880/parts/20d53643-50e8-41b6-8063-3d2ac4934bb2/modules/654d1dd0-c94a-45b5-beb8-6b1de2c48015/lessons/20707806-8f14-420f-b613-4196199a88c1/project)
  + Project: [Optimize Your GitHub Profile](https://classroom.udacity.com/nanodegrees/nd880/parts/20d53643-50e8-41b6-8063-3d2ac4934bb2/modules/654d1dd0-c94a-45b5-beb8-6b1de2c48015/lessons/de38d0de-afac-4d34-a339-25c2519cf9f9/project)
  + Project: [Backtesting](https://classroom.udacity.com/nanodegrees/nd880/parts/20d53643-50e8-41b6-8063-3d2ac4934bb2/modules/02f51888-2225-43ea-93f9-337338d3e1eb/lessons/572c48d0-6d50-46e1-832a-9769383eb3c4/project)

**Estimated time: 95 days**

## Part 1.

### Lesson 4: Stock Prices

## Terminology Recap

Here's a summary of the terms you just learned:

**Stock**: An asset that represents ownership in a company. A claim on part of a corportation's assets and earnings. There are two main types, common and preferred.

**Share**: A single share represents partial ownership of a company relative to the total number of shares in existence.

**Common Stock**: One main type of stock; entitles the owner to receive dividends and to vote at shareholder meetings.

**Preferred Stock**: The other main type of stock; generally does not entail voting rights, but entitles the owner to a higher claim on the assets and earnings of a company.

**Dividend**: A partial distribution of a company's profits to shareholders.

**Capital Gains**: Profits that result from the sale of an asset at a price higher than the purchase price.

**Security**: A tradable financial asset.

**Debt Security**: Money that is owed and must be repaid, like government or corporate bonds, or certificates of deposit. Also called fixed-income securities.

**Derivative Security**: A financial instrument whereby its value is derived from other assets.

**Equity**: The value of an owned asset minus the amount of all debts on that asset.

**Equity Security**: A security that represents fractional ownership in an entity, such as stock.

**Option Contract**: A contract which gives the buyer the right, but not the obligation, to buy or sell an underlying asset at a specified price on or by a specified date

**Futures Contract**: A contract that obligates the buyer to buy or the seller to sell an asset at a predetermined price at a specified time in the future

### Lesson 5: Marcket Mechanics

**Trading stocks: Buy Side and Sell Side**

We’ve just seen that there are buyers and sellers who go through the stock exchange to buy a stock that they think will do well, or sell a stock that they wish to remove from their investments. We’ve also introduced the market maker, who serves as the counterparty of these buyers or sellers. Since every buyer needs a seller, and every seller needs a buyer, a market maker plays the role of seller to those who wish to buy, and plays the role of buyer for those who wish to sell. By convention, we refer to these market makers as the “sell side” of the finance industry. The sell side includes investment banks such as Goldman Sachs and Morgan Stanley. The buy side refers to individual investors, and investment funds such as mutual funds and hedge funds. This Nanodegree is focused on the perspective of the “buy side”. However, it’s good to learn about the “sell side”, because these are the people that the “buy side” usually does business when they enter the market to buy or sell stocks. We’ll see an important role that the “sell side” market makers play in the next video.

### Lesson 6: Data Processing

### Foundamental Information

## Fundamental Analysis

Fundamental analysis of a company involves looking at a company’s balance sheet and cash flow statements, which are usually updated every quarter, which is every three months when the company reports earnings. It’s important to keep in mind that looking at a single quarter’s metrics is only a snapshot of the company, and there are several metrics that each try to capture the health of the company, but in slightly different ways.

In a way, analyzing a company’s fundamentals is like going on a safari taking photographs of an antelope. A single still photo from one angle may tell you some things about the antelope, but taking multiple photos from different angles will give you a better view. Also, taking multiple photos over time will give you a sense of where the antelope is going. So before we introduce some commonly used metrics, please keep in mind that to get a better picture of a company that you’re trying to analyze, you’ll want to look at a collection of different measures over time.

## Sales Per Share

A company’s revenue is based on its sales over that quarter, so we can think of sales and revenue as referring to the same thing. It’s a quick way to get a sense for how a company is doing, because we don’t have to subtract out cost of sales, which depends a bit on some accounting decisions. For example, if a company sells a million smartphones for a hundred dollars each over the past 3 months, then its revenue is $100 times 1 million, or $100 million. If the company issued ten million shares, then its sales per share is $100 million divided by ten million, or $10 per share.

You may be wondering why we bother dividing sales by the number of shares. This helps shareholders get a sense of how much the sales figures might impact a change in a single share price. You can imagine that if the company only issued 10 shares, a report of higher sales than forecasted would impact each share more than if the company issued ten million shares.

Also, note that sales of $10 per share probably does not mean that the shareholders will get $10 for each share that they own, or that their stock price will increase by $10. It costs money for the company to make each smartphone. Let’s take a look at a metric that accounts for cost of sales next.

## Earnings Per Share

Earnings is the company’s revenue minus its cost of sales. Cost of sales refers to the cost of manufacturing the phone, employee wages, rent payments for office space, and the cost of equipment, like machines that make the phones. Earnings gives investors a sense of how much the equity of the company has changed over the past 3 months. Recall that stock represents a fractional ownership of a company’s equity.

Continuing with the smartphone company example, let’s say we can estimate the cost of sales per phone to be $80 per phone. If the sales per phone is $100, then the earnings per phone is $100 - $80 equals $20 per phone. With sales of one million phones, earnings would be $20 times one million, or $20 million.

With ten million shares, this is earnings of $20 million divided by ten million shares, which is $2 earnings per share.

Note again, that this $2 per share doesn’t mean that investors automatically receive an additional $2 per share in their pocket. Let’s look at one way that investors do receive some of those earnings by looking at dividends.

## Dividends Per Share

After a company has positive earnings, they may decide to either reinvest the cash in growing the company’s business. A company’s executives are usually expected to make spending decisions based on maximizing shareholder value. Whether this always happens in practice is debatable, but ideally, if the executives decide that re-investing in the business yields lower returns than an investor could gain from investing in a similar business at the same level of risk, they will give some of the earnings to shareholders as cash. This cash is referred to as dividends.

Let’s say, for example, that the smartphone company decides to return $10 million of its earnings to its shareholders. The dividend per share is then $10 million divided by 10 million, or $1 per share.

**Price to Earnings Ratio**

A term you’ll see often is price to earnings ratio, or PE ratio for short. This is the stock’s current market price divided by its most recently reported earnings per share (EPS). You can sort of interpret the PE ratio as how much the company is valued compared to how much money it made. It’s important to be careful about how we interpret a high or low PE ratio, because we can’t say whether a PE ratio is good or bad by looking at it in isolation. Let’s first look at where the price comes from. This market price of a share is based on the collective estimates by investors of the company’s current equity plus its future earnings. The future earnings are based on estimates of future cash flow, which are then adjusted to their present-day value, or Present Value (PV). This is getting a bit outside the scope of what you’ll need to know for this course, but the point we want you to remember is that the market price of a stock is based on both its current assets minus liabilities, but also estimates of the company’s future performance.

Now coming back to the PE ratio. What does it mean to have a high PE ratio? A company may have low or negative earnings, but a high stock price. Why do you think that is? You may have heard of certain startups that are valued at billions of dollars, and yet have low earnings. This is because investors expect potential for high earnings growth, based on the trajectory of past earnings growth. This also means that investors are estimating that the high stock price relative to earnings will be justified by high future earnings. On the other hand, it’s also possible that investor optimism towards the company’s future never materializes, in which case the stock may be overpriced.

Note also that a low PE ratio can also be due to different underlying reasons. An example of a company with a low PE ratio may be one that has high and stable earnings, but less expectations for future growth. Since the company may decide that its investors are better off receiving earnings as dividends instead of reinvesting earnings into the business, the earnings will be distributed as cash to shareholders. This also means that the stock price itself represents the value of the company excluding the cash that was already distributed to these shareholders. Again, keep in mind that a low PE ratio can also be a sign of something else. If a company is expected to face pressure from competitors or government regulation that reduce their expectations for future earnings, then investors may pay a lower price for each share, and that could also result in a lower PE ratio.

In practice, you’ll want to see how a company’s PE ratio compares to other similar companies in the same industry and same geographic region.

You’ll see PE ratios again in later lessons, so for now, just remember that it’s one of many ways to take a snapshot of a company’s financial health.

### Lesson 7: Stock Returns

## Log Returns and Compounding

Log returns can be convenient for calculations that involve compounding. To explain this idea, let's first discuss compounding.

### QUESTION 1 OF 2

If you invest $100 in an asset, and the rate of return is 4% per year, and the amount of interest accrued is only calculated after the money has sat in the account for 1 year, how much money do you have after 1 year?

* $102
* $108
* $104
* $116

SUBMIT

## Compounding

The idea of compounding is a simple one. Say you put $100 in a bank account that earns 4% interest per year, compounded annually. After 1 year, you have

$100 + $100\*0.04 = $104.

The next year, you have,

$104 + $104\*0.04 = $108.16,

so you earned another $4 of interest on the original $100 but also 16 cents on the $4 of interest earned last year.

Compounding is the process by which an asset’s earnings are reinvested to generate additional earnings, that is to say, earning interest on interest.

### QUESTION 2 OF 2

Let's say you invest $100 in an asset. The annual rate of interest is reported at 4%, but the asset's seller has explained that what this means is that 2% is gained over 6 months, and then interest is calculated on the investment and it's reinvested, and then the process is repeated after the next 6 months. How much money will you have at the end of 1 year?

* $104.04
* $104.00
* $102.00
* $102.04

SUBMIT

## Rates of Compounding

A statement by a bank that the interest rate on one-year deposits is 4% per year sounds straightforward and unambiguous. In fact, its precise meaning depends on the way the interest rate is measured. For an interest rate statement to be clear, the magnitude and time dependence of the rate of interest, as well as the frequency of compounding, must be clearly stated.

If the interest rate is measured with annual compounding, the bank’s statement that the interest rate is 4% means that $100 grows to \$100\times(1 + .04) = \$104$100×(1+.04)=$104 at the end of 1 year.

When the interest rate is measured with semiannual compounding, it means that 2% is earned every 6 months, with the interest being reinvested. In this case, $100 grows to \$100\times(1 + .04/2)\times(1 + .04/2) = \$100\times(1 + .04/2)^2 = \$104.04$100×(1+.04/2)×(1+.04/2)=$100×(1+.04/2)2=$104.04, at the end of 1 year.

When the interest rate is measured with quarterly compounding, the bank’s statement means that 1% is earned every 3 months, with the interest being reinvested. The $100 then grows to \$100\times(1 + .04/4)^4 = \$104.06$100×(1+.04/4)4=$104.06 at the end of 1 year.

## Continuous Compounding

Let's compare the amount of money accumulated after 1 year with the same annual rate of interest of 4%, but different rates of compounding:

\begin{array}{c c} \textbf{Compounding frequency} & \textbf{Value of \$100 after 1 year} \\ \textrm{Annually (n=1)} & \$104.00 \\ \textrm{Semi-annually (n=2)} & \$104.04 \\ \textrm{Quarterly (n=4)} & \$104.06 \\ \textrm{Monthly (n=12)} & \$104.07 \\ \textrm{Weekly (n=52)} & \$104.08 \\ \textrm{Daily (n=252)} & \$104.08 \end{array}**Compounding** **frequency**Annually (n=1)Semi-annually (n=2)Quarterly (n=4)Monthly (n=12)Weekly (n=52)Daily (n=252)​**Value** **of** **$100** **after** **1** **year**$104.00$104.04$104.06$104.07$104.08$104.08​

Looking at the table, you can see that with more frequent compounding, the value at 1 year increases but then seems to level off. If you assumed that the benefit of compounding more and more frequently had a limit, you would be right! How do we calculate this limit? Well, first we write down the formula for compounding,

p\_t = p\_{t-1}(1 + \frac{r}{n})^n*pt*​=*pt*−1​(1+*nr*​)*n*,

and then we notice that what we'd like to do is make n bigger and bigger. We want the limit as n goes to infinity. Well, it turns out that this limit is:

\lim\_{n\to\infty}\left( 1 + \frac{r}{n}\right)^n = \mathrm{e}^rlim*n*→∞​(1+*nr*​)*n*=e*r*

Compounding infinitely often is called continuous compounding. So what does this mean? Well, it means that if you wanted to calculate how much money you’d have at the end of the year if you started with $100 and compounded continuously, but at a simple annual rate of 4%, you’d calculate:

\$100 \times \mathrm{e}^{.04} = \$104.08$100×e.04=$104.08

You'll notice that the value after 1 year with continuous compounding is pretty close (it's the same if we round to two decimal places) to the value after 1 year with daily compounding.

## Continuously Compounded Return

Now, say you were trying to reverse the previous calculation. Say you knew you had $104.08 at the end of the year, and $100 at the beginning of the year, and you wanted to calculate the rate of interest as if it had been compounded continuously. You would simply invert the formula. So you’d calculate:

\$104.08/\$100 = \mathrm{e}^r$104.08/$100=e*r*

Then you'd take the natural log of both sides, and then you'd have,

\ln(\$104.08/\$100) = rln($104.08/$100)=*r*

So,

.04 = r.04=*r*

r is the continuously compounded annual return. So the continuously compounded annual return equals \ln(p\_t/p\_{t-1})ln(*pt*​/*pt*−1​). But what is this quantity? It’s just the log return! This is why you might hear log returns called continuously compounded returns.

## Additivity

Now, say we invested $100, and the monthly continuously compounded interest rate was 2%. At the end of the month, we’d have

\$100 \times \mathrm{e}^{.02} = \$102.02$100×e.02=$102.02

But if the investment continued to accrue at a monthly continuously compounded rate of 0.02 for a whole year, we’d have

\$100 \times \mathrm{e}^{.02}\times \mathrm{e}^{.02}\times \mathrm{e}^{.02}\times \mathrm{e}^{.02}\times \mathrm{e}^{.02}\times \mathrm{e}^{.02}\times \mathrm{e}^{.02}\times \mathrm{e}^{.02}\times \mathrm{e}^{.02}\times \mathrm{e}^{.02}\times \mathrm{e}^{.02}\times \mathrm{e}^{.02}$100×e.02×e.02×e.02×e.02×e.02×e.02×e.02×e.02×e.02×e.02×e.02×e.02 ... in total, 12 factors of \mathrm{e}^{.02}e.02. So we'd have

\$100 \times (\mathrm{e}^{.02\*12}) = \$127.12$100×(e.02∗12)=$127.12

Equivalently,

\$100 \times \mathrm{e}^{.24} = \$127.12$100×e.24=$127.12

Since the annual rate of continuous compounding, 0.24, is simply the sum of the monthly rates of continuous compounding, we say that the continuously compounded rate of return is additive over time.

## Annualized Rate of Return

We saw above how to calculate the annual rate of continuous compounding from the monthly rate of continuous compounding. If we just had a single monthly rate, but we assumed that the rates for all the months of the year were the same, we could extrapolate the monthly rate to an annual rate by multiplying by 12. This is called annualizing the rate of continuous compounding. Rates of return and other metrics are often converted to a common annual basis in order to make comparisons across contexts and instruments.

## Time Additivity of Log Returns

So, as you can see, the rate of continuous compounding is additive over time. Since, mathematically, the rate of continuous compounding is just the log return, this means that log returns are additive over time, and this can be very convenient. As another example,

\mathrm{log\;return\;for\;January} + \mathrm{log\;return\;for\;February}logreturnforJanuary+logreturnforFebruary

= \ln \left( \frac{p\_{\mathrm{Feb\;1}}}{p\_{\mathrm{Jan\;1}}} \right) + \ln \left( \frac{p\_{\mathrm{Mar\;1}}}{p\_{\mathrm{Feb\;1}}} \right)=ln(*p*Jan1​*p*Feb1​​)+ln(*p*Feb1​*p*Mar1​​)

= \ln(p\_{\mathrm{Feb\;1}}) - \ln(p\_{\mathrm{Jan\;1}}) + \ln(p\_{\mathrm{Mar\;1}}) - \ln(p\_{\mathrm{Feb\;1}})=ln(*p*Feb1​)−ln(*p*Jan1​)+ln(*p*Mar1​)−ln(*p*Feb1​)

= \ln(p\_{\mathrm{Mar\;1}}) - \ln(p\_{\mathrm{Jan\;1}})=ln(*p*Mar1​)−ln(*p*Jan1​)

= \ln \left( \frac{p\_{\mathrm{Mar\;1}}}{p\_{\mathrm{Jan\;1}}} \right)=ln(*p*Jan1​*p*Mar1​​)

=\mathrm{log\;return\;for\;January\;and\;February}=logreturnforJanuaryandFebruary

## Numerical Stability

Multiplication of many small numbers can result in the problem that the product is smaller than the smallest number representable in computer memory. Sometimes the computation will incorrectly yield the value 0. This is called arithmetic underflow. The use of logarithms can help with this, since it enables the representation of much smaller (and much larger) numbers. For example:

**[[Immagine che contiene screenshot

Descrizione generata automaticamente](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251/modules/ff0c8cc4-2cf0-4d10-b053-d4694d8c4ea3/lessons/23490821-c10a-4152-be81-309afd51ba89/concepts/788f09ae-8d6f-4506-a5ea-717ff0bfeb29)](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251/modules/ff0c8cc4-2cf0-4d10-b053-d4694d8c4ea3/lessons/23490821-c10a-4152-be81-309afd51ba89/concepts/788f09ae-8d6f-4506-a5ea-717ff0bfeb29)**

## Distributions of Returns and Prices

Investors are always interested in the potential appreciation or depreciation of financial assets. They'd like to be able to predict what will happen to assets in the future, hence, they'd like to be able to build models of stock prices and returns. An important first step is to think of these prices and returns as random variables, i.e. outcomes of random phenomena, that take on values as described by distributions. Distributions allow us to summarize the behavior of random variables. So, what are the distributions of returns and prices?

One strategy for getting a sense of potential future behavior is to look to the past. Let's look at some data from the stock of a familiar company with a storied past, Apple Inc.

## Returns and the Historical Record

Let's look at the adjusted closing price of Apple stock (AAPL) from 1980 up until the present.

**[[Immagine che contiene screenshot, mappa

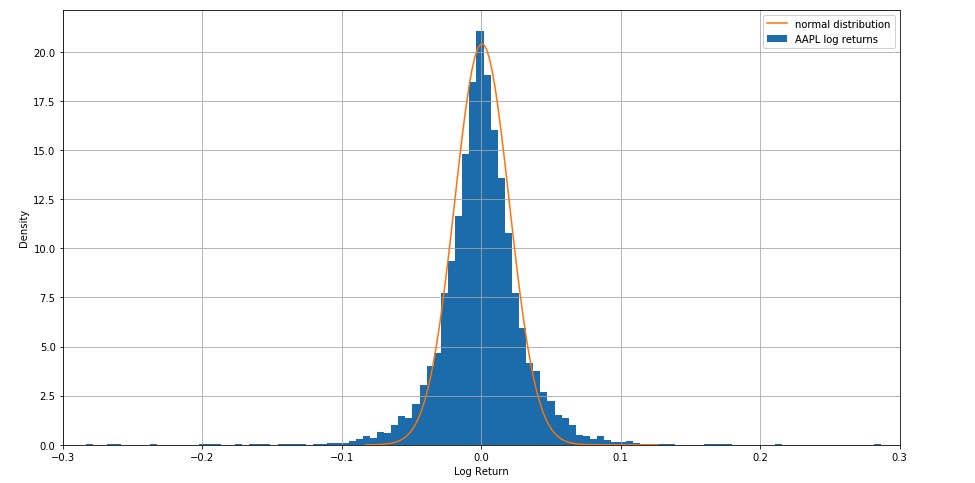
Descrizione generata automaticamente](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251/modules/ff0c8cc4-2cf0-4d10-b053-d4694d8c4ea3/lessons/23490821-c10a-4152-be81-309afd51ba89/concepts/e6aa41b3-12b9-4c6a-9ae9-a22fc8211edb)](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251/modules/ff0c8cc4-2cf0-4d10-b053-d4694d8c4ea3/lessons/23490821-c10a-4152-be81-309afd51ba89/concepts/e6aa41b3-12b9-4c6a-9ae9-a22fc8211edb)**

If we calculate returns and log returns on these data and plot them, we'll see something like the graphs below.

**[[Immagine che contiene screenshot

Descrizione generata automaticamente](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251/modules/ff0c8cc4-2cf0-4d10-b053-d4694d8c4ea3/lessons/23490821-c10a-4152-be81-309afd51ba89/concepts/e6aa41b3-12b9-4c6a-9ae9-a22fc8211edb)](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251/modules/ff0c8cc4-2cf0-4d10-b053-d4694d8c4ea3/lessons/23490821-c10a-4152-be81-309afd51ba89/concepts/e6aa41b3-12b9-4c6a-9ae9-a22fc8211edb)**

These plot look almost the same—that's because the returns and log returns for these daily data have **very similar values**. This is because daily returns are small—the values are close to 0, so the property \ln(1 + r) \approx rln(1+*r*)≈*r* applies. But we're interested in the distribution of these values, so let's look at a histogram.

**[[](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251/modules/ff0c8cc4-2cf0-4d10-b053-d4694d8c4ea3/lessons/23490821-c10a-4152-be81-309afd51ba89/concepts/e6aa41b3-12b9-4c6a-9ae9-a22fc8211edb)](https://classroom.udacity.com/nanodegrees/nd880/parts/9a3a9589-7bc6-4694-81e0-8c3cb1aea251/modules/ff0c8cc4-2cf0-4d10-b053-d4694d8c4ea3/lessons/23490821-c10a-4152-be81-309afd51ba89/concepts/e6aa41b3-12b9-4c6a-9ae9-a22fc8211edb)**

Here we've plotted a histogram of AAPL's log returns from 1980 to the present, and we've overlaid a scaled normal distribution. We can see a few things right away from this plot. First, the values are centered around 0, and in fact look roughly normal. However, the tails of the histogram clearly lie above the tails of the normal distribution. We call these "fat tails".

In general, the normal distribution can be a reasonable approximation for short-term returns and log returns for some applications. However, many analyses have shown that the data do not conform perfectly to a normal distribution, and often deviate significantly in the tails. The significance of this is that the normal distribution predicts fewer extreme events than are actually observed. The conversation about the best model for the distribution of returns has been going on for at least the past century. The best model will depend on exactly what your analysis seeks to achieve.

## Normality and Long-Term Investments

Based on historical data, it may be reasonable to consider short-term returns as approximately normally distributed for some purposes. However, even if short-term returns are normally distributed, long-term returns cannot be. If r\_1 = \frac{p\_1 - p\_0}{p\_0}*r*1​=*p*0​*p*1​−*p*0​​ and r\_2 = \frac{p\_2 - p\_1}{p\_1}*r*2​=*p*1​*p*2​−*p*1​​ are normally distributed, the sum of these, r\_1 + r\_2*r*1​+*r*2​ would be normally distributed. But the two-period return is not the sum of the one-period returns.

Two-period return = \frac{p\_2 - p\_0}{p\_0}*p*0​*p*2​−*p*0​​

\frac{p\_2 - p\_0}{p\_0} + 1 = \frac{p\_2 - p\_0}{p\_0} + \frac{p\_0}{p\_0} = \frac{p\_2}{p\_0}*p*0​*p*2​−*p*0​​+1=*p*0​*p*2​−*p*0​​+*p*0​*p*0​​=*p*0​*p*2​​

= \frac{p\_1}{p\_0}\times\frac{p\_2}{p\_1}=*p*0​*p*1​​×*p*1​*p*2​​

= (1 + r\_1)(1 + r\_2)=(1+*r*1​)(1+*r*2​)

The product (1 + r\_1)(1 + r\_2)(1+*r*1​)(1+*r*2​) is not normal, and becomes noticeably less normal as the product grows over time.

Take a look at the workspace below to get a feeling for how this occurs.

Menu

Expand

## VIDEO Teorema del limite centrale

## Distribution of Log Returns

So long-term prices and cumulative returns can be modeled as approximately lognormally distributed because they are products of independently, identically distributed (IID) random variables. On the other hand, **log returns** sum over time. Therefore, if R\_1 = \ln\left(\frac{p\_1}{p\_0}\right)*R*1​=ln(*p*0​*p*1​​) and R\_2 = \ln\left(\frac{p\_2}{p\_1}\right)*R*2​=ln(*p*1​*p*2​​) are normal, their sum, the two-period log return, is also normal. Even if they are not normal, as long as they are IID, their long-term sum will be approximately normal, thanks to the Central Limit Theorem. This is one reason why using log returns can be convenient for modeling purposes.

Why Log Returns?

### Why Log Returns?

Let's summarize what we just learned. These are some generally accepted reasons that quantitative analysts use log returns:

1. Log returns can be interpreted as continuously compounded returns.
2. Log returns are time-additive. The multi-period log return is simply the sum of single period log returns.
3. The use of log returns prevents security prices from becoming negative in models of security returns.
4. For many purposes, log returns of a security can be reasonably modeled as distributed according to a normal distribution.
5. When returns and log returns are small (their absolute values are much less than 1), their values are approximately equal.
6. Logarithms can help make an algorithm more numerically stable.

Stepping back, it may not be immediately obvious why all these attributes are benefits. Don't worry about this. As you progress in this course and beyond, you will see more applications of returns and log returns in trading strategies and algorithms and you'll be able to better appreciate why they are used.

### Lesson 8: Momentum Trading

### Long and Short Positions

### Portfolio

A portfolio is a collection of investments held and/or managed by an investment company, hedge fund, financial institution or individual.

### Long

A long (or long position) is the purchase of an asset under the expectation that the price of the asset will rise.

### Short

A short (or short position) is the selling of an asset under the expectation that the price of the asset will decline. In practice, an investor profits from a short position by borrowing shares from a brokerage firm (agreeing to pay an interest rate as a fee), selling them on the open market, and later buying them back on the open market at a lower price and returning them to the brokerage firm.

### Combining Long-Short (Clarification)

Note that the example in the video had some simplifying assumptions, where each stock has the same number of dollars invested, so that the portfolio weights for each stock are the same. It also includes the simplifying assumption that both the long and short portfolio have the same dollar amount invested (in terms of absolute magnitude), in which case the combination of the long and short portfolios would also be the simple average between the two. To correct the video, this should be (long + short) / 2; where the short is a negative value.

### Disambiguation of the term “Alpha”

You will hear the term “alpha” throughout this program, so we want to let you know early on that the term “alpha” is used to mean multiple things in the investment industry.

In mathematics, you’ll see alpha refer to the significance level of a hypothesis test. In regression, you’ll see alpha refer to the y-intercept of a straight line.

In finance, alpha refers to multiple distinct but somewhat related ideas. The common thread among these definitions is that alpha is the extra value that an investment professional can add to the performance of an investment.

One specific definition of alpha is the extra return that an actively managed fund can deliver, that exceeds the performance of passively investing (buy and hold) in a portfolio of stocks. Another specific definition of alpha, which we’ll primarily focus on in this course, is that of an alpha vector.

An alpha vector is a list of numbers, one for each stock in a portfolio, that gives us a signal as to the relative future performance of these stocks. You’ll learn more about alpha vectors throughout term 1.

Just to be clear, the finance community, both in academia and industry, use alpha to denote multiple ideas.

In this lesson, you may have noticed that we use “alpha” in the statistical sense when we talked about hypothesis testing. We also used it when saying that we may “find alpha” in a strategy. This second usage refers to outsized performance, or better-than-passive performance that a finance professional can add to an investment. Later on, we will use it in the sense of an alpha vector, which is a list of numbers that give us a signal about the relative performance of each stock.

### Lesson 10: Quant Workflow

### Immagine che contiene screenshot Descrizione generata automaticamente