P1_Trading_With_Momentum

July 25, 2019

Project 1: Trading with Momentum ## Instructions Each problem consists of a function to implement and instructions on how to implement the function. The parts of the function that need to be implemented are marked with a `# TODO` comment. After implementing the function, run the cell to test it against the unit tests we've provided. For each problem, we provide one or more unit tests from our `project_tests` package. These unit tests won't tell you if your answer is correct, but will warn you of any major errors. Your code will be checked for the correct solution when you submit it to Udacity.

Packages When you implement the functions, you'll only need to you use the packages you've used in the classroom, like Pandas and Numpy. These packages will be imported for you. We recommend you don't add any import statements, otherwise the grader might not be able to run your code.

The other packages that we're importing are `helper`, `project_helper`, and `project_tests`. These are custom packages built to help you solve the problems. The `helper` and `project_helper` module contains utility functions and graph functions. The `project_tests` contains the unit tests for all the problems.

Install Packages

Load Packages

Market Data ### Load Data The data we use for most of the projects is end of day data. This contains data for many stocks, but we'll be looking at stocks in the S&P 500. We also made things a little easier to run by narrowing down our range of time period instead of using all of the data.

```
        date ticker   adj_close
0 2013-07-01      A 29.99418563
1 2013-07-02      A 29.65013670
2 2013-07-03      A 29.70518453
3 2013-07-05      A 30.43456826
4 2013-07-08      A 30.52402098
```

```
Loaded Data
```

View Data Run the cell below to see what the data looks like for `close`.

```
ticker                A          AAL          AAP         AAPL         ABBV  \
date
2013-07-01 29.99418563 16.17609308 81.13821681 53.10917319 34.92447839
2013-07-02 29.65013670 15.81983388 80.72207258 54.31224742 35.42807578

ticker              ABC          ABT          ACN         ADBE          ADI  ...  \
date                                                                         ...
2013-07-01 50.86319750 31.42538772 64.69409505 46.23500000 39.91336014  ...
2013-07-02 50.69676639 31.27288084 64.71204071 46.03000000 39.86057632  ...

ticker               XL         XLNX          XOM         XRAY          XRX  \
date
2013-07-01 27.66879066 35.28892781 76.32080247 40.02387348 22.10666494
2013-07-02 27.54228410 35.05903252 76.60816761 39.96552964 22.08273998

ticker              XYL          YUM          ZBH         ZION          ZTS
date
2013-07-01 25.75338607 45.48038323 71.89882693 27.85858718 29.44789315
2013-07-02 25.61367511 45.40266113 72.93417195 28.03893238 28.57244125

[2 rows x 495 columns]
```

	A	AAL	AAP	...
)13-07-(	29.994	16.176	81.138	...
)13-07-(	29.650	15.820	80.722	...
)13-07-(	29.705	16.128	81.237	...
)13-07-(	30.435	16.215	81.822	...
)13-07-(	30.524	16.311	82.951	...
)13-07-(	30.689	16.715	82.436	...
)13-07-1	31.178	16.532	81.990	...
)13-07-1	31.460	16.725	82.000	...
)13-07-1	31.480	16.908	81.911	...
)13-07-1	31.728	17.100	82.615	...
...	...	...	...	...

Stock Example Let's see what a single stock looks like from the closing prices. For this example and future display examples in this project, we'll use Apple's stock (AAPL). If we tried to graph all the stocks, it would be too much information.

Resample Adjusted Prices

The trading signal you'll develop in this project does not need to be based on daily prices, for instance, you can use month-end prices to perform trading once a month. To do this, you must first resample the daily adjusted closing prices into monthly buckets, and select the last observation of each month.

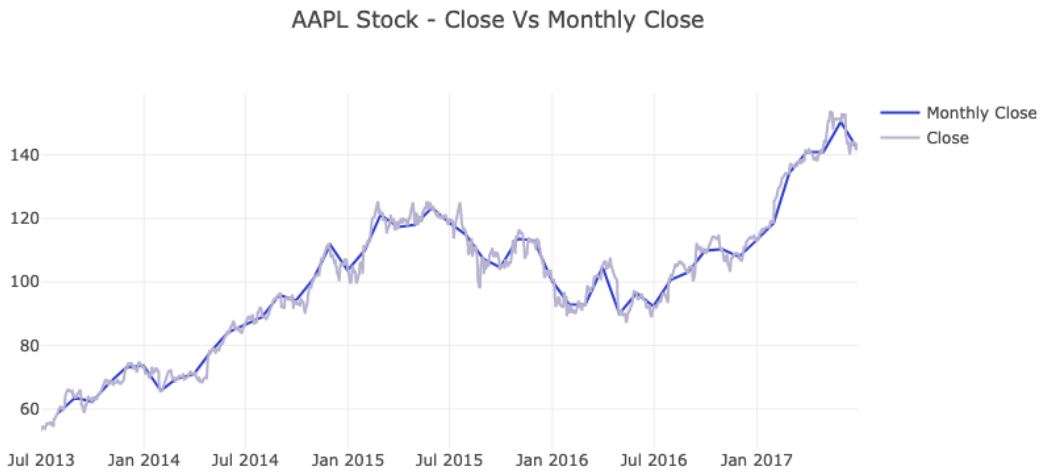
Implement the `resample_prices` to resample `close_prices` at the sampling frequency of `freq`.

```
In [ ]: def resample_prices(close_prices, freq='M'):
            """
            Resample close prices for each ticker at specified frequency.

            Parameters
            ----------
            close_prices : DataFrame
                Close prices for each ticker and date
            freq : str
                What frequency to sample at
                For valid freq choices, see http://pandas.pydata.org/pandas-docs/stable/timeseries.html

            Returns
            -------
            prices_resampled : DataFrame
                Resampled prices for each ticker and date
            """
            return ...
```

```
Tests Passed
```

View Data Let's apply this function to `close` and view the results.

```
ticker                A         AAL         AAP        AAPL        ABBV  \
date
2013-07-31 30.77861719 18.63139292 81.73270857 58.73000866 38.52144972
2013-08-31 32.09288410 15.55986096 79.33492514 63.64994327 36.09056668

ticker              ABC         ABT         ACN        ADBE         ADI  ...  \
date                                                                     ...
2013-07-31 53.87744989 32.99081455 66.22844876 47.28000000 43.44107832  ...
2013-08-31 53.01732111 30.01866909 64.82868748 45.75000000 41.01373554  ...

ticker               XL        XLNX         XOM        XRAY         XRX  \
date
2013-07-31 28.32843198 41.28388974 79.23671352 41.69639686 23.20721320
2013-08-31 26.71095532 38.60058125 74.17847651 40.83096325 23.87711213

ticker              XYL         YUM         ZBH        ZION         ZTS
date
2013-07-31 23.21996075 47.44778390 80.02819050 28.13385091 28.74031861
2013-08-31 23.18866549 45.56080402 75.81970579 26.58466104 28.10400159

[2 rows x 495 columns]
```



Compute Log Returns

Compute log returns (R_t) from prices (P_t) as your primary momentum indicator:

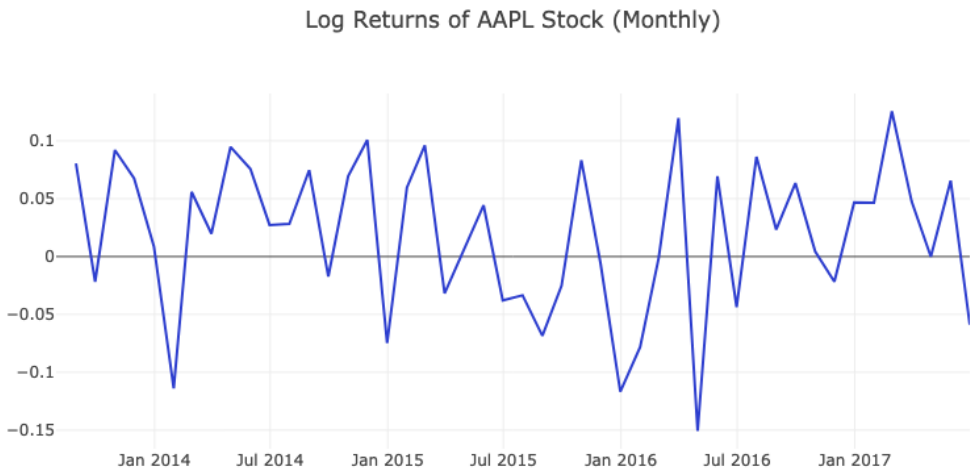
$$R_t = log_e(P_t) - log_e(P_{t-1})$$

Implement the `compute_log_returns` function below, such that it accepts a dataframe (like one returned by `resample_prices`), and produces a similar dataframe of log returns. Use Numpy's log function to help you calculate the log returns.

```
In [ ]: def compute_log_returns(prices):
            """
            Compute log returns for each ticker.

            Parameters
            ----------
            prices : DataFrame
                Prices for each ticker and date

            Returns
            -------
            log_returns : DataFrame
                Log returns for each ticker and date
            """
            return ....
```

```
Tests Passed
```

View Data Using the same data returned from `resample_prices`, we'll generate the log returns.



Shift Returns Implement the `shift_returns` function to shift the log returns to the previous or future returns in the time series. For example, the parameter `shift_n` is 2 and `returns` is the following:

```
                    Returns
             A         B         C         D
2013-07-08   0.015     0.082     0.096     0.020      ...
2013-07-09   0.037     0.095     0.027     0.063      ...
```

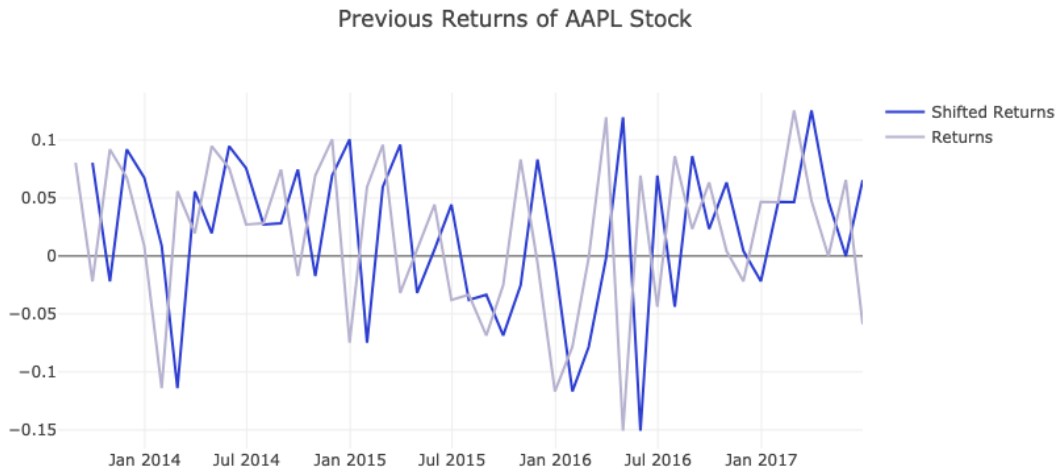
```
2013-07-10      0.094      0.001      0.093      0.019      ...
2013-07-11      0.092      0.057      0.069      0.087      ...
...             ...        ...        ...        ...
```

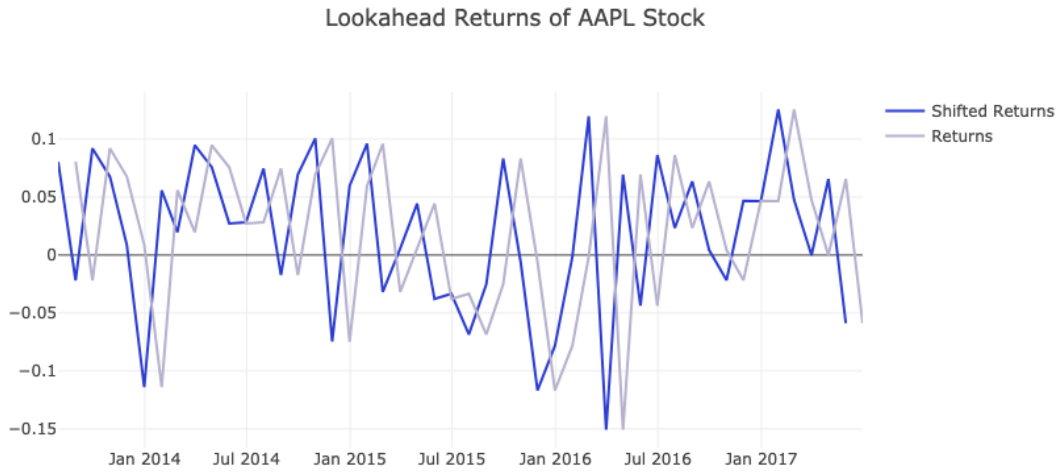
the output of the `shift_returns` function would be: `Shift Returns A B C D 2013-07-08 NaN NaN NaN NaN ... 2013-07-09 NaN NaN NaN NaN ... 2013-07-10 0.015 0.082 0.096 0.020 ... 2013-07-11 0.037 0.095 0.027 0.063 ... ... ... ... ... ...` Using the same `returns` data as above, the `shift_returns` function should generate the following with `shift_n` as -2: `Shift Returns A B C D 2013-07-08 0.094 0.001 0.093 0.019 ... 2013-07-09 0.092 0.057 0.069 0.087 ... ... ... ... ... ... ... ... ... ... ... ... ... ... ... NaN NaN NaN NaN ... ... NaN NaN NaN NaN` ... *Note: The "..." represents data points we're not showing.*

```
In [ ]: def shift_returns(returns, shift_n):
            """
            Generate shifted returns

            Parameters
            ----------
            returns : DataFrame
                Returns for each ticker and date
            shift_n : int
                Number of periods to move, can be positive or negative

            Returns
            -------
            shifted_returns : DataFrame
                Shifted returns for each ticker and date
            """
            return ...
```

```
Tests Passed
```

View Data Let's get the previous month's and next month's returns.





In [ ]:
```
''' Visual of Previous and Lookahead Returns'''
print(monthly_close_returns.head())
# 2013-07-31         nan         nan         nan         nan         nan
# 2013-08-31  0.04181412 -0.18015337 -0.02977582  0.08044762 -0.06518370
# 2013-09-30  0.09657861  0.15979244  0.03282284 -0.02171531  0.04855545
# 2013-10-31 -0.00960698  0.14734639  0.18195865  0.09201927  0.08860637
print(prev_returns.head()) # shifted one month forward
# 2013-07-31         nan         nan         nan         nan         nan
# 2013-08-31         nan         nan         nan         nan         nan
# 2013-09-30  0.04181412 -0.18015337 -0.02977582  0.08044762 -0.06518370
```

```
        # 2013-10-31  0.09657861  0.15979244  0.03282284 -0.02171531  0.04855545
        print(lookahead_returns.head()) # shifted one month backwards
        # 2013-07-31  0.04181412 -0.18015337 -0.02977582  0.08044762 -0.06518370
        # 2013-08-31  0.09657861  0.15979244  0.03282284 -0.02171531  0.04855545
        # 2013-09-30 -0.00960698  0.14734639  0.18195865  0.09201927  0.08860637
        # 2013-10-31  0.05388057  0.06647111  0.01828314  0.06772063  0.00000000
```

```
In [ ]: def get_top_n(prev_returns, top_n):
            """
            Select the top performing stocks

            Parameters
            ----------
            prev_returns : DataFrame
                Previous shifted returns for each ticker and date
            top_n : int
                The number of top performing stocks to get

            Returns
            -------
            top_stocks : DataFrame
                Top stocks for each ticker and date marked with a 1
            """
            return ...
```

```
In [16]: def get_top_n(prev_returns, top_n):
             """
             Select the top performing stocks

             Parameters
             ----------
             prev_returns : DataFrame
                 Previous shifted returns for each ticker and date
             top_n : int
                 The number of top performing stocks to get

             Returns
             -------
             top_stocks : DataFrame
                 Top stocks for each ticker and date marked with a 1
             """
             index = prev_returns.index
             output = (prev_returns.stack().groupby(level=0).rank(ascending=False) <= top_n).unstack()
             output = output.reindex(index).fillna(0).astype(int)
             return output

         project_tests.test_get_top_n(get_top_n)
```

```
Tests Passed
```

View Data We want to get the best performing and worst performing stocks. To get the best performing stocks, we'll use the `get_top_n` function. To get the worst performing stocks, we'll also use the `get_top_n` function. However, we pass in `-1*prev_returns` instead of just `prev_returns`. Multiplying by negative one will flip all the positive returns to negative and negative returns to positive. Thus, it will return the worst performing stocks.

```
top_bottom_n = 50
df_long = get_top_n(prev_returns, top_bottom_n)
df_short = get_top_n(-1*prev_returns, top_bottom_n)
project_helper.print_top(df_long, 'Longed Stocks')
project_helper.print_top(df_short, 'Shorted Stocks')
```

```
10 Most Longed Stocks:
INCY, AMD, AVGO, NFX, SWKS, NFLX, ILMN, UAL, NVDA, MU
10 Most Shorted Stocks:
RRC, FCX, CHK, MRO, GPS, WYNN, DVN, FTI, SPLS, TRIP
```

In [18]:
```
df_long.head(5)
```

Out[18]:

ticker	A	AAL	AAP	AAPL	ABBV	ABC	ABT	ACN	ADBE	ADI	...	XL	XLNX	\
date											...			
2013-07-31	0	0	0	0	0	0	0	0	0	0	...	0	0	
2013-08-31	0	0	0	0	0	0	0	0	0	0	...	0	0	
2013-09-30	1	0	0	1	0	0	0	0	0	0	...	0	0	
2013-10-31	0	1	0	0	0	0	0	0	1	0	...	0	0	
2013-11-30	0	1	1	0	0	0	0	0	0	0	...	0	0	

ticker	XOM	XRAY	XRX	XYL	YUM	ZBH	ZION	ZTS
date								
2013-07-31	0	0	0	0	0	0	0	0
2013-08-31	0	0	0	0	0	0	0	0
2013-09-30	0	0	0	0	0	0	0	0
2013-10-31	0	0	0	1	0	0	0	0
2013-11-30	0	0	0	1	0	0	0	0

[5 rows x 495 columns]

In [19]:
```
df_short.head(5)
```

Out[19]:

ticker	A	AAL	AAP	AAPL	ABBV	ABC	ABT	ACN	ADBE	ADI	...	XL	XLNX	\
date											...			
2013-07-31	0	0	0	0	0	0	0	0	0	0	...	0	0	
2013-08-31	0	0	0	0	0	0	0	0	0	0	...	0	0	
2013-09-30	0	1	0	0	0	0	1	0	0	0	...	0	0	
2013-10-31	0	0	0	1	0	0	0	0	0	0	...	0	0	
2013-11-30	0	0	0	0	0	0	0	0	0	0	...	0	1	

ticker	XOM	XRAY	XRX	XYL	YUM	ZBH	ZION	ZTS
date								
2013-07-31	0	0	0	0	0	0	0	0
2013-08-31	0	0	0	0	0	0	0	0
2013-09-30	0	0	0	0	0	0	0	0
2013-10-31	1	0	0	0	0	0	1	0
2013-11-30	0	0	1	0	1	0	0	0

[5 rows x 495 columns]

Projected Returns It's now time to check if your trading signal has the potential to become profitable!

We'll start by computing the net returns this portfolio would return. For simplicity, we'll assume every stock gets an equal dollar amount of investment. This makes it easier to compute a portfolio's returns as the simple arithmetic average of the individual stock returns.

Implement the `portfolio_returns` function to compute the expected portfolio returns. Using `df_long` to indicate which stocks to long and `df_short` to indicate which stocks to short, calculate the returns using `lookahead_returns`. To help with calculation, we've provided you with `n_stocks` as the number of stocks we're investing in a single period.

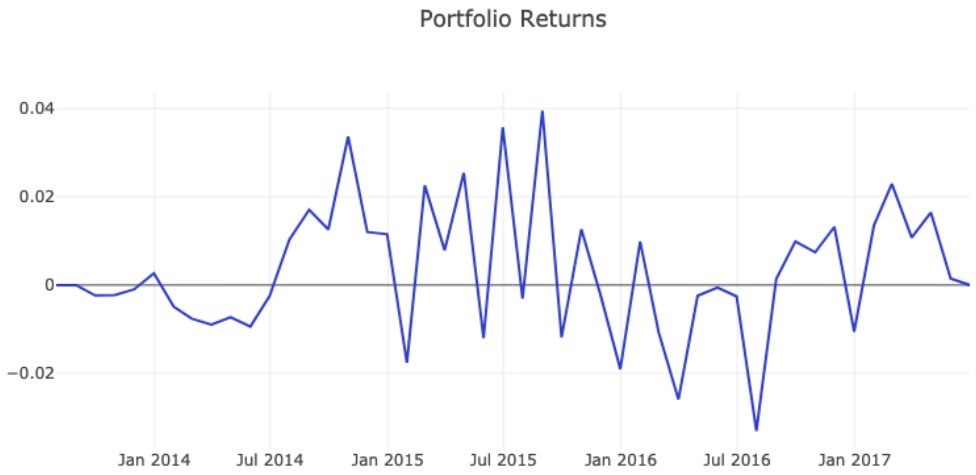
```
In [ ]: '''
        Calculate portfolio returns for each month (i.e. 2013-09-30) by multiplying the log returns fro
        the subsequent month (i.e. 2013-10-31) by your long/short positions (1,0,-1) derived from the p
        month returns (i.e. 2013-08-31) as indicated by df_long & df_short. Because each stock gets an
        dollar amount of investment, you divide each stock's log returns by the total number invested
        (2 * n_stocks) to get the amount attributed for that individual stock.
        '''
```

```
In [ ]: def portfolio_returns(df_long, df_short, lookahead_returns, n_stocks):
            """
            Compute expected returns for the portfolio, assuming equal investment in each long/short st

            Parameters
            ----------
            df_long : DataFrame
                Top stocks for each ticker and date marked with a 1
            df_short : DataFrame
                Bottom stocks for each ticker and date marked with a 1
            lookahead_returns : DataFrame
                Lookahead returns for each ticker and date
            n_stocks: int
                The number number of stocks chosen for each month

            Returns
            -------
            portfolio_returns : DataFrame
                Expected portfolio returns for each ticker and date
            """
            portfolio_returns = ...
            return portfolio_returns
```

```
Tests Passed
```

```
In [ ]: '''
        If going long, then multiply 1 by returns divided by n_stocks (5) b/c each stock gets an equal
        If going long, and returns is positive, then making money (1 * 1), if negative, then losing mon
        If going short, then multiply -1 by returns divided by n_stocks (5) b/c each stock gets an equa
        If going short, and returns is negative, then making money (- * -1), if positive, then losing m
        If went long and short on same stock, then cancels out, so zero.
        '''
```

View Data Time to see how the portfolio did.




```
ticker              A         AAL         AAP        AAPL        ABBV  \
date
2013-07-31 0.00000000 -0.00000000 -0.00000000  0.00000000 -0.00000000
2013-08-31 0.00000000  0.00000000  0.00000000 -0.00000000  0.00000000

ticker            ABC         ABT         ACN        ADBE         ADI  ...  \
date                                                                    ...
2013-07-31 -0.00000000 -0.00000000 -0.00000000 -0.00000000 -0.00000000  ...
2013-08-31  0.00000000 -0.00000000  0.00000000  0.00000000  0.00000000  ...

ticker              XL        XLNX         XOM        XRAY        XRX  \
date
2013-07-31 -0.00000000 -0.00000000 -0.00000000 -0.00000000 0.00000000
2013-08-31  0.00000000  0.00000000 -0.00000000  0.00000000 0.00000000

ticker             XYL         YUM         ZBH        ZION         ZTS
date
2013-07-31 -0.00000000 -0.00000000 -0.00000000 -0.00000000 -0.00000000
2013-08-31  0.00000000  0.00000000  0.00000000 -0.00000000  0.00000000

[2 rows x 495 columns]
```

Statistical Tests ### Annualized Rate of Return

```
Mean:                         0.003185
Standard Error:               0.002158
Annualized Rate of Return:  3.90%
```

The annualized rate of return allows you to compare the rate of return from this strategy to other quoted rates of return, which are usually quoted on an annual basis.

T-Test Our null hypothesis (H_0) is that the actual mean return from the signal is zero. We'll perform a one-sample, one-sided t-test on the observed mean return, to see if we can reject H_0.

We'll need to first compute the t-statistic, and then find its corresponding p-value. The p-value will indicate the probability of observing a t-statistic equally or more extreme than the one we observed if the null hypothesis were true. A small p-value means that the chance of observing the t-statistic we observed under the null hypothesis is small, and thus casts doubt on the null hypothesis. It's good practice to set a desired level of significance or alpha (α) *before* computing the p-value, and then reject the null hypothesis if $p < \alpha$.

For this project, we'll use $\alpha = 0.05$, since it's a common value to use.

Implement the `analyze_alpha` function to perform a t-test on the sample of portfolio returns. We've imported the `scipy.stats` module for you to perform the t-test.

Note: `scipy.stats.ttest_1samp` performs a two-sided test, so divide the p-value by 2 to get 1-sided p-value

In [ ]:
```
from scipy import stats

def analyze_alpha(expected_portfolio_returns_by_date):
    """
    Perform a t-test with the null hypothesis being that the expected mean return is zero.

    Parameters
    ----------
    expected_portfolio_returns_by_date : Pandas Series
        Expected portfolio returns for each date

    Returns
    -------
    t_value
        T-statistic from t-test
    p_value
        Corresponding p-value
    """
    t, pv_two_sided = ...
    return ...

project_tests.test_analyze_alpha(analyze_alpha)
```

```
Tests Passed
```

View Data Let's see what values we get with our portfolio. After you run this, make sure to answer the question below.

```
Alpha analysis:
 t-value:        1.476
 p-value:        0.073339
```

Question: What p-value did you observe? And what does that indicate about your signal?

Since the p-value (.074) is greater than (=0.05 normally and in this case), this means that the null hypothesis (the actual mean returned from the signal is zero) is not rejected so our result is not statistically significant.

Submission Now that you're done with the project, it's time to submit it. Click the submit button in the bottom right. One of our reviewers will give you feedback on your project with a pass or not passed grade. You can continue to the next section while you wait for feedback.