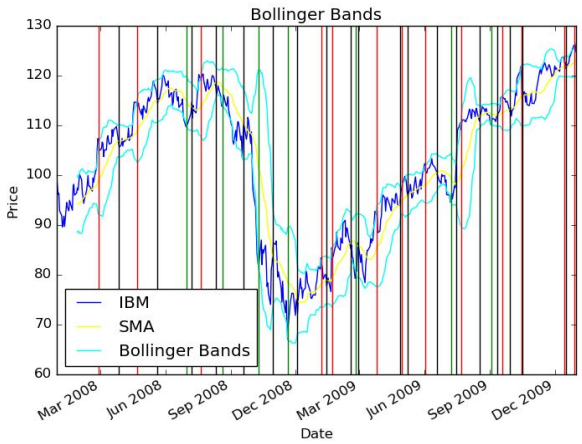
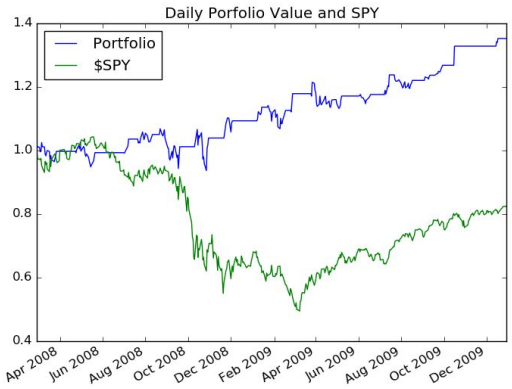
Part 1: Implementation of Bollinger Band Strategy

Bollinger Bands: In Sample Dates: 2007-12-31 to 2009-12-31	
I. Bollinger Band strategy chart showing entry and exit points.	
II. Bollinger Band strategy backtest chart.	
III. Summary of Bollinger Band backtest performance metrics.	Date Range: 2008-02-28 to 2009-12-29 Sharpe Ratio of Fund: 1.0021828373 Sharpe Ratio of SPY : $SPX 0.281344 Cumulative Return of Fund: 0.3525 Cumulative Return of SPY : $SPX -0.176562 Standard Deviation of Fund: 0.0113472701784 Standard Deviation of SPY : $SPX 0.021056 Average Daily Return of Fund: 0.000716371147921 Average Daily Return of SPY : $SPX 0.000373

	Final Portfolio Value: 13525.0

Part 2: Description and Implementation of Student Strategy

Overall: I developed my trading strategy from the **Relative Strength Indicator** (RSI), invented by J. Welles Wilder.[1] RSI with IBM data alone was able to beat Bollinger Bands strategy with in sample dates between 2007 and 2009. I tuned RSI trading indicators' buy and sell signals by tuning "high" and "low" RSI values (see strategy below), window for calculation of rolling mean (similar to rolling mean calculation for Bollinger Bands), and added a constraint to sell long or buy short when the ratio between previous and current day prices were greater than 1.0. However, when I applied the same tuned parameters to the out sample dates, 2009 to 2011, RSI did not beat Bollinger Band Strategy.

About Relative Strength Index: RSI takes into consideration the upward movement/gains and downward movement/loses in the market. This indicator measures oscillations of price movements, as well as speed of these changes. The RSI indicator is measured between zero and 100. As developed by Wilder, RSI over 70 is considered a signal for when a stock is overbought and RSI under 30 is a signal for when a stock is oversold. RSI is calculated by first finding daily changes and categorizing these changes as positive and negative daily movement. Then calculate the moving average of positive and negative daily values. According to Chart School the default window for moving averages if 14 trading days but this window can be adjusted to increase or decrease sensitivity.[2] Relative Strength (RS) is the average gain divided by average losses across the selected window. RS is calculated as RS = Moving Average Gain / Moving Average Loss. Finally, RSI normalizes the relative strength calculation so that extremes will be highlighted, where the formula: RSI = 100 - (100 / 1 + RS). Additionally, I added an additional sell long position constraint and required the daily changes in closing price to be between prices to be greater than 1.0.

[1] RSI Indicator, Trade Informed: https://www.tradinformed.com/calculate-rsi-indicator-using-excel/
[2] Relative Strength Index (RSI), Chart School: http://stockcharts.com/school/doku.php?id=chart_school:technical_indicators:relative_strength_index_rsi

Analysis of in sample dates: My trading strategy based on the RSI indicator final portfolio value exceeded the Bollinger Band strategy for **in sample dates 2007 to 2009**. These were the indicators for my strategy for in sample dates:

- Buy Long signal when RSI > 71 and sell long when RSI < 65, also called “high” values
- Buy short signal when RSI < 31 and sell short when RSI > 36, also called “low” values
- The sensitivity window of 14 days was optimal for in sample comparisons. When I increased the window to 20 days or decreased the window to 10 days, the final portfolio value were lower than Bollinger Band Strategy.
- Overall Bollinger Bands traded 40 times within the in sample period, while RSI/my strategy traded a total of 42 times.

My RSI based strategy performed better with a higher Sharpe Ratio, which denotes a better return relative to the risk that my strategy was taking. The cumulative returns between two strategies were comparable. My strategy was able to beat out Bollinger Bands on Final Portfolio value even with a slightly lower average daily return. Here, incorporating a measure of risk was able to beat Bollinger Band strategy.

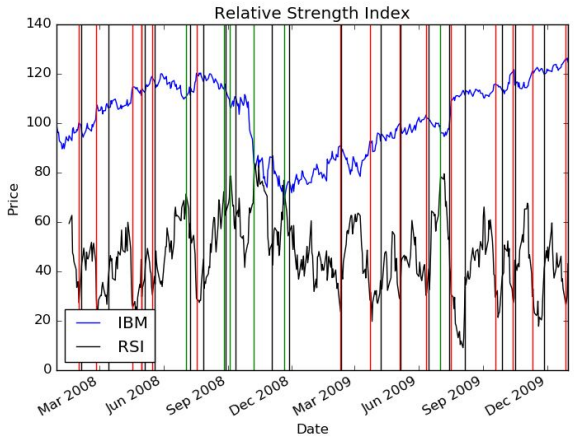
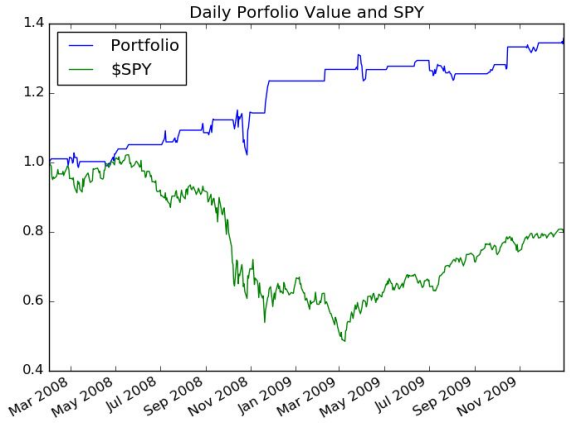
Analysis of out of sample dates: My trading strategy exceed Bollinger Band strategy for **out of sample dates 2009 to 2011,** with the following indicators changes:

- Buy Long signal when RSI > 72 and sell long when RSI < 65, also called “high” values
- Buy short signal when RSI < 33 and sell short when RSI > 35, also called “low” values
- I changed the window for rolling mean calculation to 20 days

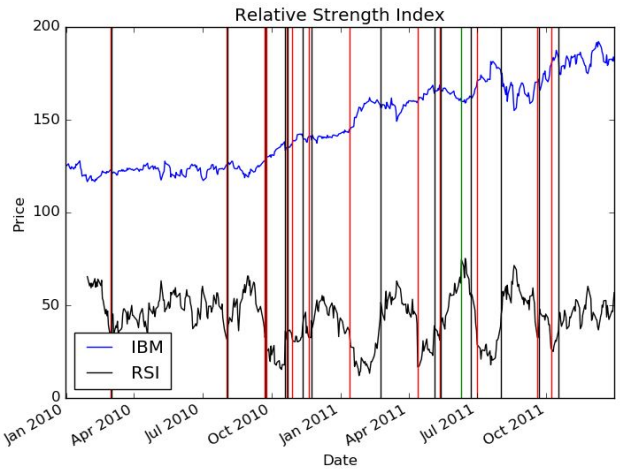
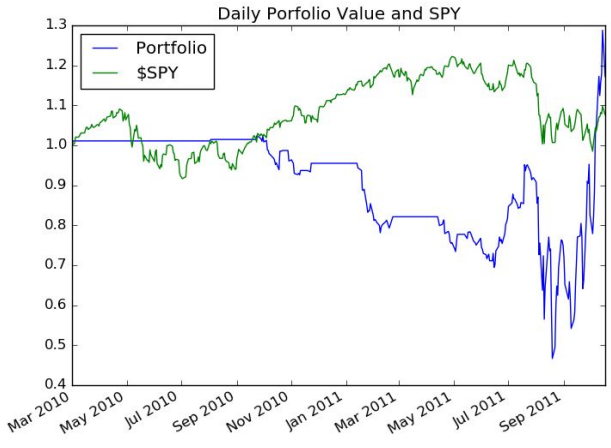
RSI with fine tuning was able to find a sweet spot to beat Bollinger Band strategy in this period. However, compared with the performance of the $SPY, this strategy did not do so well with the Bullish market trend. My strategy Sharpe Ratio was greater and lower standard deviation than Bollinger Bands in this period. Similar to the in sample period, Bollinger Bands wins on average daily returns.

However, with manual tuning, my strategy perfomed worse in the out of sample dates. IBM movement in the out of sample dates was on a general upwards with less volatility. RSI strategy was able to better interpret movements when they were signals of changing trends. Risk is an important metric and knowing how the strategies interact, next iteration I would consider combining these two indicators.

Relative Strength Index Charts and Performance Metrics:

My Strategy <u>In Sample</u> Tests and Charts	
I. RSI strategy Chart showing entry and exit points.	
II. RSI Backtest Chart	
III. Summary of RSI Backtest Performance Metrics	Date Range: 2008-02-01 to 2009-12-31 Sharpe Ratio of Fund: 1.26984313107 Sharpe Ratio of SPY : $SPX 0.198641

*Final Portfolio Value beat Bollinger Bands in sample dates, which is 13525.0.	Cumulative Return of Fund: 0.3578 Cumulative Return of SPY : $SPX -0.200886 Standard Deviation of Fund: 0.00835046236558 Standard Deviation of SPY : $SPX 0.020742 Average Daily Return of Fund: 0.000667975181684 Average Daily Return of SPY : $SPX 0.00026 **Final Portfolio Value: 13578.0**

My Strategy Out Sample Dates: December 31, 2009 to December 31, 2011	
I. RSI strategy Chart showing entry and exit points.	
II. RSI Backtest Chart	
III. Summary of RSI Backtest Performance Metrics	Date Range: 2010-03-01 to 2011-10-17

*Final Portfolio Value does not beat Bollinger Bands out sample dates, which is 11260.0	Sharpe Ratio of Fund: 0.472124092438 Sharpe Ratio of SPY : $SPX 0.386954 Cumulative Return of Fund: 0.1718 Cumulative Return of SPY : $SPX 0.076319 Standard Deviation of Fund: 0.0395942158738 Standard Deviation of SPY : $SPX 0.012695 Average Daily Return of Fund: 0.00117757245721 Average Daily Return of SPY : $SPX 0.000309 **Final Portfolio Value: 11718.0**

Part III Summary of Strategy:

In my first time working with stock data to come up with a trading strategy, limiting refining and testing to 2 years made it a manageable and interesting exercise. I was able to apply theory and ideas within a shorter period of time to achieve a goal. This strategy may not be effective in "real life" trading, especially if there is more data available for a particular stock or portfolio. There are issues of overfitting a model or strategy to a particular dataset, which is riddled with noise, nuisances, and trends. Overfitting a model or strategy provides inaccurate performance measures of how it will actually do with unknown, real life data. This can pose a considerable risk to a trading algorithm. Although it may be a good start point for me to limit backtesting to 2 year, a better practice is to back test in as many scenarios as possible. Back testing should be limited by arbitrary time and even "dummy" realistic data should be considered to test the behavior of an algorithm when applied to unknown dataset. Not fitting an algorithm or strategy to existing data is also an important consideration in machine learning.

My strategy based on RSI was able to beat Bollinger Bands with fine manual tuning for each period. In my next iteration of code, I could create a more dynamic way for RSI to feed trading signals into my algorithms. I relied too much on the manual tuning of indicators to beat Bollinger Bands, which is both not ideal and realistic in real life implementation of trading strategies.