### **Curriculum**

#### **Module 1: Course Overview**

**28:14**

 Lecture 1Overview

05:18

We discuss algo trading strategies and their recent context in the world of alternative investment management

 Lecture 2Context and Background

09:10

Introduction to the area, Algo as opposed to High-Frequency/Low Latency Trading, and areas of growth. The goals of the course, for students/academics, professionals, and algo traders, and general background to the course.

 Lecture 3What the course is Not and the Role of Data Science

06:18

What the course is not. The Role of Data science and ML - do data scientists need to know about 'canonical' strategies? Can they just start fresh? We argue that some of the most commonly used strategies give good guidance for data scientists whose techniques rarely work "out of the box" and are especially prone to problems in the area of algo trading strategies.

 Lecture 4Prerequisites and Syllabus

03:34

 Lecture 5Syllabus

03:54

We describe the basics of the syllabus. Some of these materials are covered very thoroughly, while others are covered quite quickly as methods in use / approaches to consider in devising and refining strategies. We cover Background, Momentum, Mean Reversion, Carry, Value, Basic Portfolio Strategies, and the important concept of Overfitting, focusing on the mathematical and statistical justification, formulation and properties of each strategy.

Resource 1Slides on Introduction, Background Material, Goals and Prerequisites and Syllabus

#### **Module 2: Industry Overview and Math Review**

**56:52**

 Lecture 6Industry Overview

05:10

Alternatives, Hedge Funds, CTAs and Quant Funds. What size and what numbers? How much are they growing? Where are the opportunities? From the top down look at the overall prospects of the industry where Algo Trading Strategies are employed.

 Lecture 7Tracking Funds

05:42

 Lecture 8Tracking Benchmarks

04:36

 Lecture 9Styles

04:39

 Lecture 10Algo Trading Strategy Infrastructure

04:38

 Quiz 1Intro Quiz on Background

Quiz on background and introduction

Resource 2PDF Slides

 Lecture 11Review 2 ARMA Processes

09:46

We review basic Box-Jenkins method for ARMA models, look at characteristic polynomials, describe stationary vs nonstationary processes

 Lecture 12Review 1 - White noise and Brownian motion

07:12

We review some of the basic mathematics for timeseries including white noise and brownian motion

 Lecture 13Review 3 - Autocovariance, autocorrelation and criteria

05:00

We review the ACF and its relation to ARMA models, and start on criteria (AIC, BIC) as a means of doing model choice.

 Lecture 14Review 4 - Cross Validation, Bootstrap and solving SDEs

10:09

We touch on more computer intensive methods for doing model selection - cross validation, and finding standard errors-bootstrap. Finally, we discuss two most common method for solving SDEs in closed-form, muitipying constants and integration by parts/Ito's lemma

 Quiz 2Basic ARMA models

We go through some basic ARMA models and their ACFs

#### **Module 3: Momentum / Trend Following**

**01:16:53**

 Lecture 15Momentum - a first glance

04:26

We introduce the very basic intution behind momentum and how we would construct the most simplistic of strategies

 Lecture 16Momentum Related Factoids 1

06:16

We discuss some of the properties and tradeoffs of momentum, many of which can be changed by strategy design.

 Lecture 17Momentum Factoids 2

05:01

Further factoids including examples of returns in practice

 Lecture 18Proving results about momentum 1

07:02

We look at discrete time versions of momentum and seek to prove that skewness changes by horizon

 Lecture 19Proving results about momentum 2

10:08

This is a whiteboard section on the basics of the skewness over horizon results (Martin-Zou), going through the proof, showing that the concepts are relatively easy (even if the algebra is a little tedious).

 Lecture 20Skewness - why is it so strange?

03:58

Having proved results about the skewness of momentum returns over different horizons, we apply it to an exponentially weighted moving average (EWMA) rule, showing how the peak skewness is related to the effective lookback (in our case, the "span") of the EWMA.

 Lecture 21Practical Momentum - Different methods for similar results

07:21

We describe the most commonly used methods in the industry, from Kalman Filters to Moving Averages to ARIMA models. Used properly, most of these models can attain almost the same performance.

 Lecture 22Coding Momentum 1

10:46

We introduce an ipython notebook. It takes data from Quandl (and some from Yahoo finance) including SPX, SPTR, and Effective Fed Funds. We use these to construct S&P 500 excess returns, and compare to SPX. We then devise a strategy for momentum.

 Lecture 23Coding Momentum 2

05:38

Computing relevant stats (Sharpes and Skewness) over different horizons

 Lecture 24Momentum variants, and fads and fancies in models

05:10

Cross sectional vs Timeseries momentum. Which is better? Where are each of them used? Why should we know them both? Fads and fancies in momentum modelling. Models vs Method.

 Lecture 25Momentum - capped, floored and otherwise altered signals

03:45

We look at Winsorising or capping and flooring the signals (sometimes needed to prevent too large capacity utilisation), using thresholds, etc. These typically detract from the skewness, but they could help the overall performance. We look at various methods and discuss their pros and cons and how to measure them.

 Lecture 26Readings for further study

04:20

We give links to and summarize the handful of most important papers on statistical aspects of momentum trading for further study. Being well-known, these are also the most cited papers, and so any new academic research can be found (using google scholar) just by searching preprints and papers which cite these important studies.

 Lecture 27Momentum - Summary

03:02

Summarizing the main points we made in section 2 on Momentum

#### **Module 4: Mean Reversion / Change-points**

**01:46:02**

 Lecture 28Mean Reversion Overview and Time-scales of trades

08:03

Overview of MR, and the timescales/horizons associated with MR, Momentum and Value

 Lecture 29Putting timescales all together and where to search for history

06:41

A continuation of the previous lecture, putting the timescales all together, and looking to ancient history (if need be)

 Lecture 30Mean Reversion in action

04:28

The typical features of an MR trading strategy, what to expect and what to be careful with

 Lecture 31Rationales for Mean Reversion

06:56

Various competing (or not so competing) rationales for mean reversion: Liquidity Provision and Overreaction

 Lecture 32Vol and Mean Reversion

07:46

Volatility and Mean Reversion, the theory and empirics behind their relationship

 Lecture 33Liquidity - References

03:05

A few of the most important academic papers on liquidity

 Lecture 34Mean Reversion and Unit Root Tests, Intro

04:51

An analysis of the types of behaviour we want to discern between, focusing on mean reverting vs unit root processes.

 Lecture 35Augmented Dickey Fuller Tests

05:19

ADF Tests are the most commonly used unit root tests out there. We introduce their use and limitations

 Lecture 36KPSS Tests

03:45

KPSS tests turn H0 and H1 on their heads, testing for mean-reversion. They also have their limitations

 Lecture 37Variance Ratio Tests

04:08

We introduce variance ratio tests, explore their use and misuses

 Lecture 38Cointegration and Johansen Test

09:35

Cointegration and Engle Granger testing, and the more thorough Johansen test

 Lecture 39Harvey Nyblom Tests and Shortcomings

04:27

Harvey Nyblom is to Johansen as KPSS is to ADF and we explore H-N Tests and then the shortcomings for all testing methods

 Lecture 40Power, Type I and Type II errors

04:16

power of tests, confidence intervals, type 1 and type 2 errors

 Lecture 41RV Trades

04:47

RV Trade ideas and MR

 Lecture 42Filters

07:24

 Lecture 43Changepoints - Overview

08:57

Overview and more classical approaches to changepoint detection. These are useful for piecewise linear fits to data to establish trending means and mean reversion to these trending means.

 Lecture 44Changepoints - Lasso based tools

06:17

Using the lasso regression to detect trends, we can identify breakpoints and extract trends at the same time. While not always the easiest method, regularisation methods like lasso are helpful in many circumstances and also are a decent framework to think of the underlying problems.

 Lecture 45Changepoints - sequential binary segmentation, switching kalman filters and summary

05:17

We follow up with a very practical and implementable tool - sequential binary segmentation (and Wild binary segmentation)

Resource 3

 Quiz 3

#### **Module 5: Carry, Value, and Portfolio Strategies**

**54:24**

 Lecture 46Carry - First definitions

06:05

We define carry and give a rationale in terms of P vs Q measures

 Lecture 47P vs Q measure

04:23

We continue the discussion of the differences between P measure (physical world) vs Q measure (for pricing and hedging derivatives). While Q (where spot rates will always drift towards forwards or - 'forwards are realised') is an interesting construct, it is merely that. We have to use it to price and hedge (or 'risk manage') derivatives. Realistically, in incomplete markets, Q is not actually unique and is merely a useful construct. Realistically speaking, spot rates tend to stay put, and random walks are much more likely than having realised forwards. If spot rates are martingales/random walks, this is a perfectly decent rationale for studying carry.

 Lecture 48Defining Carry

03:52

Defining carry-- what is it? Why do we care about it? What is a positive carry position and what is a negative carry position? What about commodities?

 Lecture 49Carry for Swaps (and a little for bonds)

05:03

We define carry for swaps, something not as easily available, and also a little bit for bonds. Bonds, however, are altogether more difficult, since you need to know bond-specific funding rates (term repo rates), so we mostly pursue carry for swaps.

 Lecture 50Carry for Futures, FX, Equities and Derivatives

06:50

We briefly describe carry for Futures (including commodity and equity) and FX and for the less well covered area of Derivatives.

 Lecture 51Carry - Summary

03:31

We summarize the exploration of carry

 Lecture 52Value

06:16

We define value, its use and how it differs from Equities (where it is well defined and followed regularly) to fixed income, fx and commodities. Value, with its longer-term mean-reversion properties, is naturally orthogonal to momentum, and mean-reversion.

 Lecture 53Portfolio Strategies 1 - MVO

06:43

Mean variance optimisation as a guide to basics of portfolio strategy

 Lecture 54Portfolios - Testing weights

05:07

We present portfolio optimisation as a regression and describe F-tests for statistical significance of changes in portfolio weights.

 Lecture 55Portfolio Optimisation - Conditional Portfolios and other performance measures

06:34

We introduce conditional portfolios and optimisation to include dynamic reallocation. Using augmented portfolios allows us to consider dynamic signals in portfolio optimisation. Finally, we talk about the shortcomings of most MVO style portfolio optimisation, and introduce a number of the standard performance measures used in measurement and allocation problems.

Resource 4Slides as PDF

#### **Module 6: Overfitting**

**36:41**

 Lecture 56Intro to Overfitting and the major issues

04:16

We introduce the problem and related issues of p-hacking, lack of reproducibility, and holdout overfitting in Kaggle competitions.

 Lecture 57Overfitting in Finance

05:27

Overfitting in finance is perhaps more problematic than any other field. While Amazon or Google could miss a few keyclicks by relying on spurious results, in finance, we could easily risk insolvency. Meanwhile, overfitting is altogether too common and recent studies have shown its prevalence.

 Lecture 58Dealing with overfitting - increasing backtest length

04:02

Bailey et al have proposed increasing backtest lengths to avoid overfitting. The method is illustrative but provides more of a rule of thumb. We describe the results of their paper on "Financial Charlatanism and Pseudo-Mathematics" and the concept of minimum backtest length

 Lecture 59Adjusted Sharpe Ratios and Multiple Hypothesis Tests

06:11

Harvey and Liu discuss the statistics of Sharpe ratios, converting to p-values (if Sharpe = E[Ret]/Std[Ret], the test is H0: E[Ret]=0). They then discuss multiple hypothesis testing and how one deals with it.

 Lecture 60Multiple Hypothesis Testing - Holm and Bonferroni

06:55

Ways of dealing with Multiple Hypothesis Testing - Holm and Bonferroni methods, somewhat more extreme than optimal but giving some good insight into means of adjusting p-values.

 Lecture 61Multiple Hypothesis Testing - BHY adjustments and Practical Methods to prevent overfitting

09:50

We describe the best method for controlling the rate of false discovery (FDR), the BHY adjustment and we talk about its impact on Sharpe Ratios based on number of strategies run and size of history available for backtest. Finally, we summarize the practical approaches to backtest overfitting.

Resource 5

#### **Module 7: Course Summary**

**07:08**

 Lecture 62Course Summary

07:08