

# Master of Science in Analytics

## Course Syllabus

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### Time Series Analysis and Forecasting

MSCA 31006

Wednesday 6-9 p.m. CST

Spring 2021

3/31/2021 to 6/2/2021

Location: Remote

Instructor: John Navarro

(312) 804-8488

[jfnavarr@uchicago.edu](mailto:jfnavarr@uchicago.edu)

TA/Grader: TBD

### COURSE DESCRIPTION

The objective of this course is to enable students to utilize various modeling frameworks on time series data. This course will cover classic statistical methods, curve-fitting methods, state-space modeling and Machine Learning and Deep Learning modeling methods. Students will learn applications of these modeling methodologies through hands on modeling in both Python and R.

### PREREQUISITES

Required: Students need to have taken Linear Algebra and Statistical Analysis. Students need to be familiar with R and Python for data processing and model development.

### COURSE MATERIALS

Required:

[FPP] Hyndman, R. and Athanasopoulos, G. *Forecasting: Principles and Practice*. OTexts. 2014.

Available online at <https://otexts.com/fpp3/>

Optional:

[PTS] Nielsen, A. *Practical Time Series Analysis*. O'Reilly, 2020.

[MJK] Montgomery, D.C., Jennings, C.L. and Kulahci, M. *Introduction to Time Series Analysis and Forecasting*. 2<sup>nd</sup> Edition, Wiley, 2015.

[TSA] Cryer, Jonathan D. and Kung-Sik Chan. *Time Series Analysis with Applications in R*. 2<sup>nd</sup> Edition. Springer, 2008.

### SOFTWARE

The statistical software package R version 3.6.3 or higher is used for this course. It is freely available from <http://cran.rstudio.com/>. Documentation is available at <http://www.r-project.org/>.

The statistical software package Python version 3.6 or higher is to be used for this course. It is freely available from <http://www.python.org/>.

Recommend Jupyter Notebook (<http://jupyter.org/>) for Python code development.

### LEARNING OBJECTIVES

After completing this course, students should be able to:

- Understand how to explore, visualize, and clean time series data
- Determine what type of modeling framework and solution to use for various time series datasets.
- Understand and verbalize modeling forecasts, the uncertainty around these forecasts and the limitations of the model.

## EVALUATION

Grades for the course will be based on the following:

- |                       |     |
|-----------------------|-----|
| • Assignments (7)     | 35% |
| • Quizzes (6)         | 15% |
| • Class Participation | 10% |
| • Course Project      | 40% |

**Assignments:** There are 7 assignments, each posted on canvas with a due date. The assignments are created to test the students' understanding of conceptual materials, application of methodologies and communication of results. Thorough explanations and defense of opinions are expected.

**Quizzes:** There will be 6 in class quizzes throughout the quarter. This will test the student's understanding of materials covered in class (either synchronous or asynchronous material).

**Class Participation:** Participation will be comprised of two portions. First, completion of asynchronous material. Second, students are expected to participate in discussion during the class. This can be during the lecture portion, the workshop portion or quiz review. Each week will comprise 1/10<sup>th</sup> of the final participation grade.

**Course Project:** The purpose of the project is to test the students' ability to apply time series methods to a real-world forecasting problem. The components of this project include the following:

- Selection of a real world time series problem and forecasting objective
- Prepare and analyze the time series data
- Develop a number of forecast models, equal to the number of group members
- Evaluate forecasting metrics and propose a single solution
- Understand the limitations of the forecast and potential improvements
- Effectively communicate the results of the analysis

## GRADING SCALE

A = 93%–100%  
A- = 90%–92%  
B+ = 87%–89%

|      |         |
|------|---------|
| B =  | 83%–86% |
| B- = | 80%–82% |
| C+ = | 77%–79% |
| C =  | 73%–76% |
| C- = | 70%–72% |
| F =  | 0%–69%  |

## COURSE SCHEDULE

Academic quarters consist of 9 weeks of instruction, with the 10th week for assessment or course rescheduling. Refer to the university's academic calendar at [www.uchicago.edu/academics/calendar/](http://www.uchicago.edu/academics/calendar/) for quarterly start and end dates.

**Important Note:** Changes may occur to the syllabus at the instructor's discretion. When changes are made, students will be notified via email and in-class announcement.

### **Week 1 Introduction to Time Series FPP 1, 2, 7**

- Class introductions and syllabus review
- Forecasting Introduction
- Regression
- Time series concepts
- Stationarity

### **Week 2 Early Statistical Methods FPP 3, 5, 8**

- Naïve methods
- Decomposition
- Smoothing methods
- Residual diagnostics
- Model evaluation and accuracy
- Holt Winters
- Dealing with data inconsistencies

### **Week 3 ARIMA Models FPP 9**

- Wold Decomposition
- Box-Jenkins ARMA and ARIMA
- Model evaluation
- Model Diagnostics

### **Week 4 Advanced ARIMA FPP 9,10**

- Auto ARIMA
- Seasonal ARIMA
- Regression with ARMA errors
- ARIMAX
- ARFIMA

**Week 5 Using Prophet**

- Saturating Forecasts
- Trend Changepoints
- Seasonality
- Additional Regressors
- Non-Daily Data
- Hyperparameter tuning

**Week 6 More Statistical Methods FPP 11, 12**

- VAR and VARIMA
- Hierarchical Time Series
- Outlier Detection

**Week 7 Machine Learning and Deep Learning Methods PTS 11-12**

- sktime package
- Bootstrapping Bagging, Random Forest
- RNN

**Week 8 State Space Models PTS 7**

- Kalman Filter
- Hidden Markov Models
- BSTS

**Week 9 Additional Topics**

- Spectral Analysis
- TBATS
- Transfer Functions
- Intervention Analysis
- ARCH/GARCH

**Week 10 Final projects**

- Each group submits one set of slides prior to session 10 start

**ATTENDANCE**

This course will meet weekly via zoom. Your attendance is required and paramount to your success in this class. You are allowed to miss at most two sessions, provided that you make arrangements with the instructor in advance.

In order to allow students to follow quarantine guidelines, instructors should be prepared to offer students the ability to complete their coursework remotely while they self-isolate. All students that require accommodations for COVID-related absences should be referred to their current area Dean of Students, [dosgraham@uchicago.edu](mailto:dosgraham@uchicago.edu).

Students who have been exposed to or who are experiencing symptoms of COVID-19 should contact [UChicago Student Wellness](#) immediately to be tested, and reach out to their area Dean of Students to request accommodations for classes

- At least 10 days have passed since symptoms first appeared and;
- At least 3 days (72 hours) have passed since recovery- defined as resolution of fever without the use of fever-reducing medications and improvement in respiratory symptoms (e.g., cough, shortness of breath).

## LATE WORK

All assignments must be submitted to this course's Canvas site on the assignment due date before the start of class (6pm). If you turn in an assignment late, 20% credit will be deducted from the total score for each day after the deadline. Assignments turned in more than one week late will not receive credit. In the case of unexpected events, you must contact the instructor (cc the grader) before the assignment due date in order to receive a grace period. Students can only receive up to 2 grace periods in the course.

## REQUESTING REASONABLE ACCOMODATIONS

The University of Chicago is committed to ensuring equitable access to our academic programs and services. Students with disabilities who have been approved for the use of academic accommodations by [Student Disability Services](#) (SDS) and need a reasonable accommodation(s) to participate fully in this course should follow the procedures established by SDS for using accommodations. Timely notifications are required in order to ensure that your accommodations can be implemented. Please meet with me to discuss your access needs in this class after you have completed the SDS procedures for requesting accommodations.

Phone: (773) 702-6000

Email: [disabilities@uchicago.edu](mailto:disabilities@uchicago.edu)

Please follow accommodation implementation instructions provided by the disability liaison in the division after you have completed the SDS procedures for requesting accommodations.

You may want to begin by reading through the information published on this website

<https://disabilities.uchicago.edu/>.

## ACADEMIC HONESTY & PLAGIARISM

It is contrary to justice, academic integrity, and to the spirit of intellectual inquiry to submit another's statements or ideas of work as one's own. To do so is plagiarism or cheating, offenses punishable under the University's disciplinary system. Because these offenses undercut the distinctive moral and intellectual character of the University, we take them very seriously.

Proper acknowledgment of another's ideas, whether by direct quotation or paraphrase, is expected. In particular, if any written or electronic source is consulted and material is used from that source, directly

or indirectly, the source should be identified by author, title, and page number, or by website and date accessed. Any doubts about what constitutes "use" should be addressed to the instructor.

Academic Honesty and Plagiarism sites:

<https://studentmanual.uchicago.edu/academic-policies/academic-honesty-plagiarism/>  
<https://internationalaffairs.uchicago.edu/page/honest-work-and-academic-integrity-plagiarism>

Copyright site: <http://www.lib.uchicago.edu/copyrightinfo/>

## STUDENT HEALTH PACT

All students on campus are required to adhere to the guidelines in the UChicago Health Pact in order to create a safe environment in the classroom.

- Secure face coverings must be worn appropriately at all times while in University buildings
- Maintain a distance of 6 feet from others
- Do not attend an in-person class if you feel unwell or are experiencing COVID-19 related symptoms

The complete text of the UChicago Health Pact along with additional information about COVID-19 protocols can be found [here](#).

## REPORTING COVID-19 RELATED CONCERNS

Any concerns over inappropriate PPE usage, physical distancing, cleaning/disinfection, or other COVID-19 related public health concerns should be directed to [UCAIR](#). If there is an emergency, call 773-702-8181 or dial 123 on any campus phone.

## REPORTING COVID-19 EXPOSURE OR A CONFIRMED CASE

If you were potentially exposed to COVID-19 or your COVID-19 test results come back positive, reach out immediately to [C19HealthReport@uchicago.edu](mailto:C19HealthReport@uchicago.edu).

## RECORDING AND DELETION POLICIES FOR ACADEMIC YEAR 2020-2021

The Recording and Deletion Policies for the current academic year can be found in the Student Manual under [Petitions, Audio & Video Recording on Campus](#).

- Do not record, share, or disseminate any course sessions, videos, transcripts, audio, or chats.
- Do not share links for the course to those not currently enrolled.
- Any Zoom cloud recordings will be automatically deleted 90 days after the completion of the recording.