Mathematics 328 – Time Series Analysis

I. Identification

A. School of Arts and Science
B. Mathematics
C. MAT 328
D. Number has never been used
E. Time series analysis
F. The course is aimed at providing a solid introduction to the methods and underlying theory of modern time series analysis. The main focus will be on modeling and forecasting second order stationary processes with ARMA models. The latter part of the course may cover more advanced/specialized topics like spectral analysis, state-space models, and GARCH models. Applications will involve the use of R.
G. The prerequisite is a grade of C- or better in MAT 326 and MAT372 or equivalent. There are no special conditions.
H. Probable Texts:
Shumway & Stoffer (2011) Time Series Analysis and its applications, with examples in R , 3rd edition, Springer.

Brockwell & Davis (2016) Introduction to Time Series and Forecasting, 3rd edition, Springer

Prado & West (2010) Time Series: Modeling, Computation, and Inference Chapman & Hall Petris,

Ruppert & Matteson (2016) Statistics and Data Analysis for Financial Engineering with R examples, 2nd Edition, Springer

I. Prepared by Yulei Pang
J. To be determined

II. Rationale

A. This course is being proposed as a part of the anticipated undergraduate data science program. This course aimed at providing a solid introduction to the methods and underlying theory of modern time series analysis. The main focus will be on modeling and forecasting second order stationary processes with ARMA models. The latter part of the course may cover more advanced topics like spectral analysis, state-space models, and GARCH models. Applications will involve the use of R.
B. This course will not be cross-listed
C. This course will likely be taken by students in the (anticipated) Data Science program.

III. Course Description

The course is meant to be a continuation of a data science class, which will equip students with various forecasting techniques and knowledge on modern statistical methods for analyzing time series data. Although the course will have a theoretical component it will be practical and exercise-driven. The Analyses will be performed using the freely available package astsa, which accompanies the book. Both R and RStudio will be required for this class.

A. Student Learning Outcomes

1. To understand the basic concepts in time series analysis space-time models
2. To know ARIMA modeling of stationary and nonstationary time series
3. To know how to choose an appropriate forecasting method in a particular environment.
4. To improve forecast with better statistical models based on statistical analysis
5. To critically review and evaluate time series models
6. To understand the limitations of the methods
7. To convey relevant aspects of modeling issues and results, for example in the role of a data scientist/engineer
8. To build a good foundation for further studies and the ability to take in new developments in the field.

B. Course Outline

1. Characteristics of Time Series (16%)

The Nature of Time Series Data
Time Series Statistical Models
Measures of Dependence: Autocorrelation and Cross-Correlation
Stationary Time Series
Estimation of Correlation

2. Time Series Regression and Exploratory Data Analysis (14%)

Classical Regression in the Time Series Context
AIC/ BIC
Exploratory Data Analysis
Smoothing in the Time Series Context

3. ARIMA Models (32%)

Autoregressive Moving Average Models
Difference Equations
Autocorrelation and Partial Autocorrelation
Forecasting
Estimation
Integrated Models for Nonstationary Data
Building ARIMA Models
Multiplicative Seasonal ARIMA Models(Optional)

4. Spectral Analysis and Filtering (14%)

The Spectral Density
Nonparametric Spectral Estimation
Linear Filters

Lagged Regression Models

5. **Additional Time Domain Topics** **(10%)**
   Long Memory ARMA and Fractional Differencing
   GARCH Models

6. **State-Space Models** **(14%)**
   Filtering, Smoothing, and Forecasting
   Maximum Likelihood Estimation
   Bootstrapping State-Space Models
   Missing Data Modifications (Optional)

Table for MAT 328 Contact Hours

Learning Activity	Weekly Hours Spent towards course	Total Hours spent for 15 week course	Semester Credits Earned
In-Class Time Lecture / Lab	3.5	52.5	------
Text Reading	1	15	------
Mathematical Homework Assignments	2	30	------
Statistical Project Assignments Using R software	2	30	------
Total Hours	8.5	127.5	3

7. Modes of Instruction
   Mathematics 328 may follow a lecture format with homework assignments. Use of a computer package is required. A computer lab session is recommended. The course may also be offered as a hybrid course, where some sessions meet virtually.

8. Evaluation
   Exams = 50% Projects = 25% Homework=25%

Outcome	**Evaluation**
To understand the basic concepts in time series analysis space-time models	Evaluated by homework and exams
To know ARIMA modeling of stationary and nonstationary time series	Evaluated by homework, exams and project
To know how to choose an appropriate forecasting method in a particular	Evaluated by homework and project

environment.	
To improve forecast with better statistical models based on statistical analysis	Evaluated by homework, exams and project
To critically review and evaluate time series models	Evaluated by homework and project
To understand the limitations of the methods	Evaluated by homework, exams and project
To convey relevant aspects of modeling issues and results, for example in the role of a data scientist/engineer	Evaluated by homework and project
To build a good foundation for further studies and the ability to take in new developments in the field.	Evaluated by homework and exams

In addition to homework, which will be graded, students will have a final project that they will complete to assess the skills. The final project will also be collected and graded.

9. Bibliography (Style used by American Mathematical Society)

Brockwell & Davis (2016) Introduction to Time Series and Forecasting, 3rd edition, Springer

Prado & West (2010) Time Series: Modeling, Computation, and Inference Chapman & Hall Petris,

Ruppert & Matteson (2016) Statistics and Data Analysis for Financial Engineering with R examples, 2nd Edition, Springer