Math 641: Time Series Analysis I

Spring 2022

Instructor:	Hadi Safari Katesari	**Meeting:**	Monday 6:30 - 9:05 PM
Email:	hsafarik@stevens.edu	**Place:**	Gateway North 103

Office Hours: Monday 4:30-6:15 PM.

Office: Kidde 229,

Main References:

- *Time Series Analysis with Applications in R*, 2nd Edition, by Jonathan D. Cryer, and Kung-Sik Chan.
- *Multivariate Time Series Analysis: With R and Financial Applications*, 2nd Edition, by Ruey S. Tsay.
- *Time Series Analysis and Its Applications: With R Examples*, 4th Edition, by Robert H. Shumway, David S. Stoffer.

Objectives:

- Scope and applications of time series analysis: process control, financial data analysis and forecasting, and signal processing. Exploratory data analysis: graphical analysis, trend and seasonality detection and removal, and moving-average filtering. Review of basic statistical concepts related to the characterization of stationary processes. ARMA models and prediction of stationary processes. Estimation of ARMA models and model building and forecasting with ARMA models. Spectral analysis: periodogram testing for seasonality and periodicities and the maximum entropy and maximum-likelihood estimators. Asymptotic convergence. Selected topics, such as multivariate time series, nonlinear models, Kalman filtering, econometric forecasting, and long-memory processes. Selected applications, such as the unit-root problem in economics, forecasting and testing for market efficiency in financial time series, process control, and quality control.
- After successful completion of this course, students will be able to: Summarize and plot time series data in statistical format; Apply stationary (ARMA) and nonstationary (ARIMA) time series models; Apply model specification and diagnostic for stationary and nonstationary times series models; Compute parameter estimation for time series models via statistical methods such as maximum likelihood; Predict the values for time series at future time points and interpret the results; Apply statistical techniques into seasonal time series (SARMA) modeling; Identify well-known time series models such as ARCH and GARCH. Apply spectral analysis, nonlinear models, and threshold models; Apply multivariate time series analysis.

Prerequisite(s): MA 540 (Introduction to Probability Theory)

Grading Policy:

- Grades will be based on the following:
  - Homework (30%)
  - Midterm: (25%)
  - Final Exam (25%)
  - Research Project (20%)
- The letter-grade cutoffs are as below:
  A: 85-100 A-: 81-84 B+: 77-80 B: 73-76 B-: 69 -72 C: 60-68 F : 00-59

Programming:

> Some of the homework questions and final project will involve basic programming with R.
>
> We will use R in this course. You are expected either to know R or to learn it quickly (by example). The R package is available for free from www.r-project.org. Read carefully the "Introduction to R" Appendix in Cryer and Chan (starts on page 423).

Course Requirements:

- **Attendance:** Students are encouraged to attend each session and to participate in the discussion. Attendance will be taken into account in borderline cases.
- **Homework:** There will be periodic homework assignments during the semester, with due dates given in the course calendar. In each homework assignment, there exist multiple applied and theoretical problems. You need to complete ONLY 4 questions for each homework assignment. For completing additional question(s), you will be given extra grade. Homework should be submitted online in time, and no late homework will be accepted. The format of homework submissions should be only a pdf file. R code and output must be included. In this regard, you are encouraged to apply R Markdown. If you are using your handnotes, then you are encouraged to apply a scanner software such as CS.
- **Individual Research Project:** You will be asked to work individually on a research project related to material in the course, which should result in a short 'paper'. The detailed instruction of the individual research project will be added to the Canvas shell as a pdf file.
- **Exams:** Closed-book, one double-sided, letter size, cheat-sheet is allowed for the exam. Non-programmable calculators are allowed. Computers/tablets/cell phones/smart watches, and any other electronic devices, especially the ones with wireless communication, are not permitted. Students are not allowed to work with or talk to other students during the exam. The date of midterm exam will be announce at least one week before the date of the midterm exam. Moreover, details will be discussed one week before the exams. Students are needed to be present in the dates of the (midterm and final) exams. The (midterm and final) exams will not be repeated unless you have strong documention (e.g., from health provider/hospital) which shows that you are not able to attend the exam (e.g., due to health problem).

Tentative Weekly Schedule:

[*CC*] Time Series Analysis with Applications in R, 2nd Edition, by Jonathan D. Cryer, and Kung-Sik Chan.

[*T*] Multivariate Time Series Analysis: With R and Financial Applications, 2nd Edition, by Ruey S. Tsay.

[*SS*] Time Series Analysis and Its Applications: With R Examples, 4th Edition, by Robert H. Shumway, David S. Stoffer.

- **Week 1**: [*CC*] Chapter 1 and 2
  Introduction, Fundamental Concepts, Nature of Time Series Data with Examples, Stochastic Process, White Noise, Means, Variances, and Covariances, Random Walk, Stationarity.

- **Week 2**: [*CC*] Chapter 3
  Deterministic and Stochastic Trends, Regression Methods, Cyclical or Seasonal Trends, Cosine Trends, Interpreting Regression Output, Reliability and Efficiency of Regression Estimates
  Time Series Lab with R.

- **Week 3**: [*CC*] Chapter 4.1-4.3
  Models for Stationary Time Series I, General Linear Processes, Moving Average Processes, MA(p), Autoregressive Processes, AR(q), Yule-Walker equations.

- **Week 4**: [*CC*] Chapter 4.4-4.5
  Models for Stationary Time Series II, Mixed Autoregressive Moving Average Model, ARMA(p,q), Invertibility, Stationarity Region for an AR(2) Process, Autocorrelation Function for ARMA(p,q)
  Time Series Lab with R.

- **Week 5**: [*CC*] Chapter 5
  Models for Nonstationary Time Series, Stationarity Through Differencing, ARIMA Models, Constant Terms in ARIMA Models, Transformations, Backshift Operator.

- **Week 6**: [*CC*] Chapter 6
  Model Specification, Sample, Partial, and Extended Autocorrelation Function, Nonstationarity, Overdifferencing, The Dickey-Fuller Unit-Root Test
  Time Series Lab with R.

- **Week 7**: [*CC*] Chapter 7
  Parameter Estimation, Method of Moments, (Unconditional) Least Squares Estimation, Maximum Likelihood Estimators, Asymptotic Properties of the Estimates, Bootstrapping ARIMA Models.

- **Week 8**: Midterm Exam; [*CC*] Chapter 1-7.

- **Week 9**: [*CC*] Chapter 8
  Model Diagnostics, Residual Analysis, Normality and Autocorrelation of the Residuals, Ljung-Box Test, Identifiability, Overfitting and Parameter Redundancy
  Time Series Lab with R.

- **Week 10**: [*CC*] Chapter 9
  Forecasting, ARIMA Forecasting, Prediction Limits, Updating ARIMA Forecasts, Forecast Weighted Moving Averages, Forecasting Transformed Series, State Space Models, Kalman filtering.

- **Week 11**: [*CC*] Chapter 10
  Seasonal Models, Seasonal ARIMA Models, Multiplicative Seasonal ARMA Models, Nonstationary Seasonal ARIMA Models, Seasonal Model Specification, Fitting, and Checking, Forecasting Seasonal Models
  Time Series Lab with R.

- **Week 12**: [*CC*] Chapter 12; [*SS*] Chapter 5.1
  Time Series Models of Heteroscedasticity, Some Common Features of Financial Time Series, ARCH Models, GARCH Models, Long Memory ARMA and Fractional Differencing.

- **Week 13**: [*CC*] Chapter 13 and 15
  Spectral Analysis, Periodogram, Discrete Fourier Transform, Linear Filters, Empirical Examples, Nonlinear Models, Threshold Models
  Time Series Lab with R.
- **Week 14**: [*T*] Chapter 2 and 3
  Multivariate Time Series Analysis, VAR Models, VMA Models, VARMA Models
  Final Exam Review.

Academic Integrity: All Stevens graduate students promise to be fully truthful and avoid dishonesty, fraud, misrepresentation, and deceit of any type in relation to their academic work. A student's submission of work for academic credit indicates that the work is the student's own. All outside assistance must be acknowledged. Any student who violates this code or who knowingly assists another student in violating this code shall be subject to discipline. All graduate students are bound by the Graduate Student Code of Academic Integrity by enrollment in graduate coursework at Stevens. It is the responsibility of each graduate student to understand and adhere to the Graduate Student Code of Academic Integrity. More information including types of violations, the process for handling perceived violations, and types of sanctions can be found at www.stevens.edu/provost/graduate-academics.

Learning Accommodations: Stevens Institute of Technology is dedicated to providing appropriate accommodations to students with documented disabilities. The Office of Disability Services (ODS) works with undergraduate and graduate students with learning disabilities, attention deficit-hyperactivity disorders, physical disabilities, sensory impairments, psychiatric disorders, and other such disabilities in order to help students achieve their academic and personal potential. They facilitate equal access to the educational programs and opportunities offered at Stevens and coordinate reasonable accommodations for eligible students. These services are designed to encourage independence and self-advocacy with support from the ODS staff. The ODS staff will facilitate the provision of accommodations on a case-by-case basis.

Disability Services Confidentiality Policy: Student Disability Files are kept separate from academic files and are stored in a secure location within the Office of Disability Services. The Family Educational Rights Privacy Act (FERPA, 20 U.S.C. 1232g; 34CFR, Part 99) regulates disclosure of disability documentation and records maintained by Stevens Disability Services. According to this act, prior written consent by the student is required before our Disability Services office may release disability documentation or records to anyone. An exception is made in unusual circumstances, such as the case of health and safety emergencies. For more information about Disability Services and the process to receive accommodations, visit https://www.stevens.edu/oce-disability-services. If you have any questions please contact: Phillip Gehman, the Director of Disability Services Coordinator at Stevens Institute of Technology at pgehman@stevens.edu or by phone (201) 216-3748.

Name and Pronoun Usage: As this course includes group work and in-class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect. This includes the ability for all students to have their chosen gender pronoun(s) and chosen name affirmed. If the class roster does not align with your name and/or pronouns, please inform the instructor of the necessary changes.

Inclusion Statement: Stevens Institute of Technology believes that diversity and inclusiveness are essential to excellence in academic discourse and innovation. In this class, the perspective of people of all races, ethnicities, gender expressions and gender identities, religions, sexual orientations, disabilities, socioeconomic backgrounds, and nationalities will be respected and viewed as a resource and benefit throughout the semester. Suggestions to further diversify class materials and assignments are encouraged. If any course meetings conflict with your religious events, please do not hesitate to reach out to your instructor to make alternative arrangements. Students are expected to treat the instructor and all other participants in the course with courtesy and respect. Disrespectful conduct and harassing statements will not be tolerated and

may result in disciplinary actions.

Mental Health Resources: Part of being successful in the classroom involves a focus on your whole self, including your mental health. While you are at Stevens, there are many resources to promote and support mental health. The Office of Counseling and Psychological Services (CAPS) offers free and confidential services to all enrolled students who are struggling to cope with personal issues (e.g., difficulty adjusting to college or trouble managing stress) or psychological difficulties (e.g., anxiety and depression). Appointments are strongly encouraged and can be made by phone (201-216-5177) or in-person (on the 7th floor of the Howe Center). CAPS is open from 9:00 AM till 5:00 PM Mondays, Wednesdays, Thursdays and Fridays and from 9:00 AM till 7:00 PM on Tuesdays during the Fall and Spring semesters.

Emergency Information: In the event of an urgent or emergent concern about the safety of yourself or someone else in the Stevens community, please immediately call the Stevens Campus Police at 201-216-5105 or on their emergency line at 201-216-3911. These phone lines are staffed 24/7, year round. Other 24/7 resources for students dealing with mental health crises include the National Suicide Prevention Lifeline (1-800-273-8255) and the Crisis Text Line (text "Home" to 741-741). If you are concerned about the wellbeing of another Stevens student, and the matter is not urgent or time sensitive, please email the CARE Team at care@stevens.edu. A member of the CARE Team will respond to your concern as soon as possible.

Refresh Links:

- http://www.mathwords.com/d/derivative$_r$*ules.htm*
- http://www.mathwords.com/i/integral$_r$*ules.htm*
- https://homedir.jct.ac.il/ naiman/la1/
- https://homedir.jct.ac.il/ naiman/la2/

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