University of Toronto
Department of Statistical Sciences

STA457H1-S/STA2202H-S (LEC5101) – Time Series Analysis

Syllabus: Summer 2023

Land Acknowledgement
We wish to acknowledge the land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca, and most recently,the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.

Resource: native-land.ca

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Course Formats Highlights
This course is an in-person course. Any deviations from this document will be announced on Quercus. Please keep visited regularly the website link FAS student FAQs.

1. **Course logistics (Instructor and Team, Class time, Office hours)**

This is an in-person course.

Instructor: Esam Mahdi
Email: e.mahdi@utoronto.ca

Class Day/Time:

Lecture	Room	First lecture	Last day to drop S courses
Monday 6 – 9 pm	BA 1160	July 5, 2023	July 31, 2023
Wednesday 6 – 9 pm	BA 1160		

We will follow "U of T time" and begin 10 minutes past the hour.

Instructor's Office hour: Tuesday 2:00 – 3:00 pm via zoom-link (https://utoronto.zoom.us/j/88077826295) or email for an appointment. Any update/change will be announced in Quercus.

Teaching assistants, emails, and office hours: The TA office hours will be online as follows:

TA	Email	Office hours				
		Monday	Tuesday	Thursday	Friday	Link to meeting
Vedant Choudhary	vedant.choudhary@mail.utoronto.ca	4-5 pm				https://utoronto.zoom.us/j/86390164798?from=addon Meeting ID: 863 9016 4798 Passcode: 902245
Yovna Junglee	yovna.junglee@mail.utoronto.ca		3-4 pm			https://utoronto.zoom.us/j/88535647433
Zhengyu Li	douying.li@mail.utoronto.ca			6-7 pm		https://utoronto.zoom.us/j/9391552252
Junhao Zhu	jh.zhu@mail.utoronto.ca				4-5 pm	https://utoronto.zoom.us/j/4650179228 Meeting ID: 465 017 9228 Passcode: JoeZhu98

Additional office hours (2-hours for midterm examination and 2 -hours for final examination) as follows:

TA	Email	Midterm	Final Exam	Link to meeting
		Date	Date	
Vedant Choudhary	vedant.choudhary@mail.utoronto.ca	July 24 (3:30-5:30)	August 16 (3:30-5:30)	https://utoronto.zoom.us/j/86390164798?from=addon Meeting ID: 863 9016 4798 Passcode: 902245
Yovna Junglee	yovna.junglee@mail.utoronto.ca	July 25 (10-12)	August 16 (10-12)	https://utoronto.zoom.us/j/88535647433
Zhengyu Li	douying.li@mail.utoronto.ca	July 25 (2-4)	August 17 (2-4)	https://utoronto.zoom.us/j/9391552252
Junhao Zhu	jh.zhu@mail.utoronto.ca	July 25 (5-7)	August 17 (10-12)	https://utoronto.zoom.us/j/4650179228 Meeting ID: 465 017 9228 Passcode: JoeZhu98

All course materials (e.g., lecture slides/announcement/suggested questions etc.) will be available on Quercus and links therein (https://q.utoronto.ca). For security reasons, please do not copy or share contents anywhere.

The majority of course communication and announcements will happen through Quercus. It is your responsibility to check Quercus regularly.

Communicating with the Instructor

Before emailing your instructor, please:

- re-read this syllabus to see if the answer is already here,
- check the announcement and modules posted on Quercus,
- ask your Teaching Assistant (TA),
- post your questions to Piazza,
- meet during office hours.

If your question is not answered after looking through these resources, then please email the instructor.
When emailing your instructor, please use the subject line: STA457 H1-S/STA2202 H-S. If this subject is not included, your email may be missed.

Discussion Board

- You have the option to use [Piazza](#) for class discussion. If you decide not to use [Piazza](#), it will not disadvantage you in any way, and will not affect official University outcomes (e.g., grades and learning opportunities). If you choose not to opt-into [Piazza](#), then you can ask questions or discuss course material with the instructor or TAs during office hours. Be sure to read Piazza's Privacy Policy (https://piazza.com/legal/privacy) and Terms of Use (https://piazza.com/legal/terms) carefully. Take time to understand and be comfortable with what they say. They provide for substantial sharing and disclosure of your personal information held by Piazza, which affects your privacy. If you decide to participate in Piazza, only provide content that you are comfortable sharing under the terms of the Privacy Policy and Terms of Use.

- Piazza is a free online gathering place where students can ask, answer, and explore 24/7, under the guidance of your instructor. Rather than emailing questions to the teaching staff, we encourage you to post your questions on Piazza.

- Before posting a question, double-check the syllabus and search to see if someone else has already asked a similar question.

- Try to answer your classmates' questions — this is a great way to reinforce your own understanding while also helping your classmates! Don't worry if you aren't sure of the answer—answers will be reviewed/endorsed/amended by the teaching team! To sign up for the discussion forum click on the link: https://q.utoronto.ca/courses/324034/external_tools/18207 Course Overview

Course Description:

This course provides an overview of methods and problems in the analysis of time series data. Topics include: descriptive methods, filtering and smoothing time series, theory of stationary processes, identification and estimation of time series models, forecasting, seasonal adjustment, spectral estimation. Further topics, such as long memory, fractional differencing, and ARCH/GARCH models, will be covered. The course will cover both theoretical and practical aspects of time series analysis, making extensive use of the R statistical software.

Intended Learning Outcomes
By the end of the course, you will be able to:
- Understand the characteristics and nature of time series.
- Perform time series modelling, estimating, forecasting and present the results using real-world problems.
- Build a solid theoretical background for the subject.
- Use statistical software R with time series analysis.

Prerequisites: STA302H1/STAC67H3/STA302H5; MAT235Y1/MAT237Y1/MAT257Y1/(MATB41H3, MATB42H3)/(MAT232H5, MAT236H5)/(MAT233H5, MAT236H5). If you do not have this prerequisite, you should see the undergraduate coordinator in the Department of Statistical Sciences to obtain a waiver form.

Exclusion: STAD57H3, STA457H5

2. **Course Materials, Textbooks & Supplementary Learning Resources**

- The **main textbook** for the course is: *[Time Series Analysis and Its Applications, with R examples](#), Springer Texts in Statistics, 4th Ed. (2017), by Robert H. Shumway, David S. Stoffer.*

- **Recommended Textbook:** The following books are also good references for this course:

  - *[Time Series Analysis with Applications in R](#), Springer Texts in Statistics, 2nd Ed., (2008) by Jonathan D. Cryer and Kung-Sik Chan.*
  - *[Time series analysis univariate and multivariate methods](#). Pearson Education, New York, 2nd Ed. (2006) by William W.S. Wei.*
  - *[Forecasting: Principles and Practice](#), 3rd, by R.J. Hyndman and G. Athanasopoulos.*
  - *[Forecasting, Time series, and Regression](#), Duxbury Press, 4th edition, (2005) by Bruce Bowerman, Richard O'Connell, and Anne Koehler.*

Topics to be covered:

Characteristics of Time Series:
- Introduction, Time series data, Time series plots.
- Time series statistical models (stationary and non-stationary), Pre-processing and filtering.
- Measures of dependence, Autocovariance and Autocorrelation.

Time Series Regression
- Linear regression model and model selection.
- Regression with lagged variables, involving trigonometric terms, Smoothing, differencing, transformations.

ARIMA Models
- Autoregressive model, Moving Average model, Mixed autoregressive-moving average (ARMA) models.
- MA in an infinite AR representation, AR in an infinite MA representation.
- Autocorrelation and partial autocorrelation function of ARMA models, Test for stationarity (Dickey-Fuller test).
- Forecasting ARMA models, Durbin-Levinson algorithm, Yule-Walker equations, Model diagnosis.
- Regression with autocorrelated errors, Detecting autocorrelation (Durbin–Watson test), Multiplicative seasonal ARIMA (SARIMA) models.

Additional Time Domain Topics
- Spectral analysis (spectral density and covariance functions), Long memory ARMA and fractional differencing, ARCH and GARCH models.

3. **Computations**

We will use R for all examples. R is freely available for download at http://cran.rproject.org for Windows, Mac, and Linux operating systems. It is strongly recommended that you also download R Studio (www.rstudio.com) to accompany R for a nicer user interface. You can also use the server version of RStudio on https://jupyter.utoronto.ca. Al students and faculty have access to this resource. This means that you don't have to download and install R and RStudio. If you are interested in learning to replicate the work done in the video lectures, there are option R videos that walk you through the syntax and steps in R. It is highly recommended to use the R-Markdown (see https://rmarkdown.rstudio.com/).

Calculators (for in-person tests/exams)

You will need a calculator. Any calculator that has logarithmic functions will be sufficient. Calculators on phones or other devices equipped to communicate with the outside world (for example, through the internet or cellular or satellite phone networks) will not be permitted during the term tests or final exam.

4. **Assessments & Grading**

Homework assignment will be completed online (Crowdmark). Midterm and final exams will be completed in-person, i.e., on paper under invigilation.

5.1 Marking Scheme
- 30%   Homework (HW) assignments (3 assignments, so each worth 10%)
- 30%   Midterm Test (in-person during class time at a location that will be specified on Quercus)
- 40%   Final Assessment (in-person as specified by the Faculty of Arts and Science later)

5.2 Assessment Details

Assessment	Modules covered (see Section 9)	Due Date (duration)
HW 1	1, 2	July 16 (Sunday, 11:59 pm)
HW 2	3	July 23 (Sunday, 11:59 pm)
Midterm Test	1, 2, 3, 4	July 26 (Wednesday, 7:30 – 9:00 pm; 90 mins) Location: BA 1160
HW 3	4, 5	August 13 (Sunday, 11:59 pm)
Final Assessment	All modules	TBA (August 17 – 25, 2023)

TBA: To be announced (on Quercus).

5.3 Homework assignments

The homework assignments will be posted on [Crowdmark](#) as pdf files. You need to organize your solution, showing your steps clearly and in detail. You have to submit the solution before the due time at 11:59 pm. It is highly recommended to use the R-Markdown (see https://rmarkdown.rstudio.com/) for creating pdf solution files.

Late Penalty for Homework Assignments

For the homework submitted via [Crowdmark](#), a 25% per day penalty will be applied to assignments that are submitted late. For example, this means that if an assignment is due at 11:59 pm, and is submitted at 12:00 am, then it will incur a 25% late penalty. If it is submitted at 12:00 am the following day, then it will incur a 50% late penalty.

Missed Homework Assignments (due to valid reasons)

There are no make-ups for missed homework assignments. If you miss a homework for a valid reason (e.g., illness or personal emergency), then (within one week following the assessment) you must fill out the absence declaration form on [ACORN](#). The declaration is available to students through [ACORN](#) under the Profile and Settings menu (More information is available [here](#); see also the [University policy for absence declaration](#)). If you miss all homework assignments for a valid reason, then a 100% weight of homework assessment will be shifted to the final (i.e., the final exam will account for 70% of the course grades). If you miss one or two homework assignments for valid reasons, then the 50% of the total weight (of 10% for each assignment you missed) will be shifted to the other homework assignment/s (i.e., 5% weight will be shifted onto the other homework/s) and the remaining to the final assessment (i.e., 5% weight will be shifted onto the final exam). Otherwise, a missed homework with no valid reason will be assigned a grade of zero.

5.4 Midterm Test

Midterm and final exams will be completed in-person, i.e., on paper under invigilation. The term test will be written during class time. For the time, date, and location, see Section 5.2. You must bring your own calculator and your student identification to the term test.

Late submission: There is no possibility of submitting term tests **late**.

Missed Midterm test

There is no make-up for missing the midterm test. If the test is missed for a valid reason (e.g., illness or personal emergency), then you must fill out the absence declaration form on [ACORN](#). The declaration is available to students through [ACORN](#) under the Profile and Settings menu (More information is available [here](#); see also the [University policy for absence declaration](#)). If the midterm test is missed due to illness or personal emergency, its 100% weight will be shifted to the final (i.e., the final will account for 70% of the course grades).

5.5 Final exam

The faculty of arts and science schedules the final exam. You will be permitted to bring a 8.5"x11" (or T4 size), **two-sided, handwritten** aid sheet. You must bring your own calculator and your student identification to the final test.

Late submission: There is no possibility of submitting the final exam **late**.

Final Exam Absences or Exemptions

If a student misses the final exam for any reason, then they should contact their College Registrar's office or work through Accessibility Services if it is a matter of accommodation.

5.6 Re-mark Requests

Any requests to have a homework assignment or term test re-marked must be made in writing to me within one week of receiving your marks. Note that it is possible for a re-mark to result in a lower grade. Requests to re-mark the final exam will be handled at the department-level.

5. **Intellectual Property**

   Course materials provided on Quercus, such as lecture slides, assignments, tests and solutions are the intellectual property of your instructor and are for the use of students currently enrolled in this course only. **Providing course materials to any person or company outside of the course is an unauthorized use**.

6. **Accessibility**

   Students with diverse learning styles and needs are welcome in this course. If you have a disability/health consideration that may require accommodations, please feel free to approach me and/or Accessibility Services as soon as possible at 416-978 8060; studentlife.utoronto.ca/as; email accessibility.services@utoronto.ca. The Accessibility Services staff are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations. The sooner you let them and me know your needs, the quicker we can assist you in achieving your learning goals in this course. More information can be found here: www.accessibility.utoronto.ca.

7. **Accommodations**

   The University of Toronto supports reasonable accommodation of the needs of students who observe religious holy days other than those already accommodated by ordinary scheduling and statutory holidays. As mentioned on the webpage below, please let me know if you require accommodations or expect absences, and I will make reasonable effort to make accommodations at these times. More information: https://www.viceprovoststudents.utoronto.ca/policies-guidelines/accommodation-religious/ .

8. **Academic Integrity**

   The University treats cases of plagiarism and cheating very seriously. It is the students' responsibility forknowing the content of the University of Toronto's Code of Behaviour on Academic Matters. All suspected cases of academic dishonesty will be investigated following the procedures outlined in the above document. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information on academic integrity from your instructor or from other institutional resources (see https://www.academicintegrity.utoronto.ca/). Here are a few guidelines regarding academic integrity:

   - You may consult class notes/lecture slides during homework, however sharing or discussing questions or answers with others is an academic offence.
   - Students must complete all assessments individually. Working together is not allowed.
   - Paying anyone else to complete your assessments for you is an academic misconduct.
   - Sharing your answers/work with others is academic misconduct.
   - Copying solutions to homework problems from online or a book is an academic offence.
   - All work that you submit must be your own! You must not copy answers from anyone or anywhere else. Unacknowledged copying or unauthorized collaboration will lead to severe disciplinary action, beginning with an automatic grade of zero for all involved and escalating from there. Read the UofT Policy on Cheating and Plagiarism, and don't plagiarize.

9. **Tentative Class Schedule**

   The lectures of this course will be posted on Quercus as beamer presentation slides. The Module numbers listed in the table below correspond to the lectures that we will cover. It is highly recommended to read these modules prior to your lecture. Any change to the schedule will be announced and posted on Quercus.

Week		Lecture (Monday + Wednesday)	What's due/important?
1	July 3 - July 7	Module 1	
2	July 10 - July 14	Module 2 + Module 3	HW 1 due July 16 (Sunday, 11:59 pm)
3	July 17 - July 21	Module 4	HW 2 due July 23 (Sunday, 11:59 pm)
4	July 24 - July 28	Midterm exam + Module 5	Midterm Exam on July 26 (Wednesday, 7:30 – 9:00 pm)
5	July 31 - August 4	Module 5	
6	August 7 - August 11	Module 6	HW 3 due August 13 (Sunday, 11:59 pm)
7	August 14	Module 7	
August 17 - August 25: Final assessments in S and Y courses			Final Assessment date TBA