

MATH 545: TIME SERIES ANALYSIS

WINTER 2025

Instructor : David A. Stephens (Burnside 1225)

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Textbooks : *Introduction to Time Series and Forecasting* (3rd Edition)

P. J. Brockwell and R. A. Davis.

Time Series Analysis and its Applications with R Examples (4th Edition)

R. H. Shumway and D. S. Stoffer.

Introductory Time Series with R

P. S. P. Cowpertwait and A. V. Metcalfe

TARGET SYLLABUS

1. **Introduction.** Simple stochastic models; Gaussian processes; stationarity; autoregressive processes; moving average processes; trends and seasonality; decomposition; differencing.
2. **Stationary Processes.** Construction; linear processes; autoregressive processes; ARMA processes; estimation for ARMA processes; forecasting; the Levinson-Durbin algorithm; partial autocorrelation; the innovations algorithm.
3. **ARMA Models: Estimation And Forecasting.** Basic properties; $ARMA(p, q)$ models; autocorrelation; forecasting; autocovariance generating function; partial autocorrelation; estimation (method of moments, maximum likelihood); model selection; residual checking.
4. **Non-Stationary And Seasonal Models.** ARIMA models; unit roots; seasonal ARIMA models; non-stationarity in mean structure.
5. **Multivariate And State-Space Models.** Vector time series models; stationarity and correlation; cointegration; state space models; linear state space models; formulation of ARMA models; the Kalman filter; hidden Markov models: estimation and inference
6. **Spectral Analysis.** Spectral representations of stationary processes; spectral representations of ARMA Models; estimation.
7. **Financial Time Series Models.** Parameter-driven models; observation-driven models; conditional heteroscedasticity; ARCH, GARCH and stochastic volatility models.
8. **Advanced Topics.** Machine learning models; continuous time models.

Week	Beginning	Lectures	Target content
1	January 6	1, 2	Simple stochastic models; Gaussian processes; stationarity
2	January 13	3, 4	Trends and seasonality; differencing; stationary processes
3	January 20	5, 6	Linear processes; autoregressive processes
4	January 27	7, 8	ARMA processes; forecasting
5	February 3	9, 10	Partial autocorrelation; computational algorithms
6	February 10	11, 12	ARMA models; autocovariance generating function; inference
7	February 17	13, 14	Model selection for ARMA models; Non-stationary modelling
8	February 24	15, 16	Seasonality and seasonal ARIMA models; other non-stationarities
9	March 3		Winter Reading Break
10	March 10	17, 18	Vector time series; VAR models; Cointegration
11	March 17	19, 20	State space models; The Kalman Filter
12	March 24	21, 22	Hidden Markov models
13	March 31	23, 24	Spectral Methods
14	April 7	25, 26	Financial time series models; advanced topics

EVALUATION

Please note that the method of evaluation for this class will be **on the following basis only**:

Assignments: Theoretical and methodological questions;
Applied questions using the R programming language (or equivalent);
Midterm: Thursday February 20th 2025;
Final: 3hr in-person exam, held during the final exam period.

Assignments: There will be **five** assignments, the best **four** of which will count equally toward the final grade. The assignments will be handed out according to the following schedule

Assignment	Week	Week Beginning
1	2	January 13th
2	4	January 27th
3	8	February 10th
4	10	March 10th
5	12	March 24th

with assignments set at the end of the week indicated.

Final grade for the course: determined by the larger of

20 % Assignments + 20 % Midterm + 60 % Final

and

20 % Assignments + 80 % Final.

There will no opportunity for make-up work in place of any aspect of the course assessment.

Policy on Late Submission:

- Late submissions may be subject to 100% penalty.
- Requests for accommodation due to extenuating circumstances should be directed to the Course Instructor (Prof. Stephens, david.stephens@mcgill.ca).

Key Academic Dates: <https://www.mcgill.ca/importantdates/key-dates>

- Add/Drop deadline: Tuesday, January 14th
- Classes end: Friday, April 11th
- Final Exam period: April 14th – April 30th.

Office Hours:

- Instructor will hold weekly Office Hours; scheduling details will be announced shortly.

myCourses:

- Official communications will take place via myCourses.
- All course materials will be available via myCourses.

MC GILL POLICY STATEMENTS

- **Policy on Assessment of Student Learning:** [Policy on Assessment of Student Learning](#)

The purpose of the Policy on Assessment of Student Learning (PASL) is to provide a set of common principles to guide the assessment of students' learning. Per PASL, assessment should be equitable and consistent, and promote effective learning experiences, a healthy learning environment, and academic integrity. Learn more on the For Students page of the PASL website. Also see Faculty of Science-specific rules on the implementation of PASL.

- **Accommodations:**

- Legally mandated academic accommodations are handled by Student Accessibility and Achievement. For more information see <https://www.mcgill.ca/access-achieve/>
- Academic considerations for assessments that are missed or late for valid reasons will be provided at the instructor's discretion. Repeated, similar requests for academic considerations in this course are unlikely to be granted.

- **Language of Submission:** *In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded. This does not apply to courses in which acquiring proficiency in a language is one of the objectives.*

Conformément à la Charte des droits de l'étudiant de l'Université McGill, chaque étudiant a le droit de soumettre en français ou en anglais tout travail écrit devant être noté, sauf dans le cas des cours dont l'un des objets est la maîtrise d'une langue.

[Charter of Students' Rights](#) (Approved by Senate on 21 January 2009)

- **Academic Integrity:** *McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures*

L'université McGill attache une haute importance à l'honnêteté académique. Il incombe par conséquent à tous les étudiants de comprendre ce que l'on entend par tricherie, plagiat et autres infractions académiques, ainsi que les conséquences que peuvent avoir de telles actions, selon le Code de conduite de l'étudiant et des procédures disciplinaires.

[Code of Student Conduct and Disciplinary Procedures](#) (Approved by Senate on 29 January 2003)

- **Extraordinary circumstances:** *In the event of extraordinary circumstances beyond the University's control, the content and/or assessment tasks in this course are subject to change. Students will be advised of the change.*
- **Copyright:** *Instructor-generated course materials (e.g., handouts, notes, summaries, exam questions) are protected by law and may not be copied or distributed in any form or in any medium without explicit permission of the instructor. Note that infringements of copyright can be subject to follow up by the University under the Code of Student Conduct and Disciplinary Procedures.*

David A. Stephens.
January 2025