Western Engineering

Western University

Faculty of Engineering

Artificial Intelligence Systems Engineering Program

AISE4010/A – DEEP LEARNING FOR TIME SERIES DATA

Course Outline Fall 2026

COURSE DESCRIPTION:

This course introduces deep learning models for time series data. In this course, the students will become familiar with sequence models and their engineering applications. The students are introduced to Recurrent Neural Networks (RNNs) and commonly - used variants such as Gated Recurrent Units (GRUs) and Long Short-Term Memory (LSTMs). In addition, the course introduces transformer architectures and their engineering applications. Students will get hands- on experience with Deep Learning from a series of practical engineering case-studies.

ACADEMIC CALENDAR: AISE 4010/A

https://www.westerncalendar.uwo.ca/Courses.cfm?CourseAcadCalendarID=MAIN_030389_1&SelectedCalendar=Live&ArchiveID=

PRE OR COREQUISITES:

Data Science 3000A/B, AISE 3010A/B.

ANTIREQUISITES: N/A

CEAB ACADEMIC UNITS:

Engineering Science 65%, Engineering Design 35%.

INSTRUCTOR INFORMATION:

Name:

Office/Office Hours:

Phone:

Email:

All communication about clarifying course material must happen on the OWL forums; questions about clarifying content sent by e-mail may be ignored. If private communication is required, use e-mail, but you must include AISE4010 in the subject line. Students must use their Western (@uwo.ca) email addresses when contacting their instructors

CONTACT HOURS:

Timetable information is available at https://draftmyschedule.uwo.ca/.

LECTURE:	(3 lecture hrs /12 times during the term)
LAB:	(2 lab and tutorial hrs /11 times during the term)

Both lectures and labs are in-person. No lectures and labs during the reading week. No lectures on September 30th.

RECOMMENDED/ REQUIRED SOFTWARE: Python

RECOMMENDED RESOURCES/REFERENCES:

- Gharehbaghi, A. (2023), Deep Learning in Time Series Analysis. CRC Press.
- Zhang, A., et al., Dive into Deep Learning, Cambridge University press. [Available at: https://d2l.ai/d2l-en.pdf]
- Goodfellow,I., Bengio, Y., Courville, A. (2016), Deep Learning. MIT press.
- Chollet, F., (2021), Deep Learning with Python, Manning Publications.
- Brownlee, J. (2018), Deep Learning for Time Series Forecasting: Predict the Future with MLPs, CNNs and LSTMs in Python, [Available at: https://books.google.ca/books?id=o5qnDwAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false]
- Nielsen, A. (2020), Practical Time Series Analysis: Prediction with Statistics and Machine Learning, O'Reilly.
- Cerqueira, V. and Roque, (2024), L. Deep Learning for Time Series Cookbook: Use PyTorch and Python Recipes for Forecasting, Classification, and Anomaly Detection. Packt Publishing.
- Gridin, I. (2021), Time Series Forecasting using Deep Learning: Combining PyTorch, RNN, TCN, and Deep Neural Network Models to Provide Production-Ready Prediction Solutions. BPB Publications.

Other Required References: Students must check OWL BRIGHTSPACE (https://westernu.brightspace.com/d2l/home/) on a regular basis for news and updates. This is the primary method by which information will be disseminated to all students in the class. Students are responsible for checking OWL BRIGHTSPACE on a regular basis.

GENERAL LEARNING OBJECTIVES (CEAB GRADUATE ATTRIBUTES)

Knowledge Base	A	Engineering Tools	A	Impact on Society	
Problem Analysis	D	Individual & Teamwork		Ethics and Equity	D
Investigation		Communication		Economics and Project Mgmt.	
Design	A	Professionalism		Life-Long Learning	

Notation: x represents the content level code as defined by the CEAB. blank = not applicable; I = introduced (introductory); D = developed (intermediate) and A = applied (advanced).

Rating: I – The instructor will introduce the topic at the level required. It is not necessary for the student to have seen the material before. D – There may be a reminder or review, but the student is expected to have seen and been tested on the material before taking the course. A – It is expected that the student can apply the knowledge without prompting (e. g. no review).

COURSE MATERIALS: Weekly content and guides for the laboratories will be available on the course OWL site.

COURSE TOPICS AND SPECIFIC LEARNING OUTCOMES:

The following table summarizes the course learning outcomes along with CEAB GAIs where the GAIs in bold indicate ones to be measured and reported annually.

COURSE TOPICS AND SPECIFIC LEARNING OUTCOMES	(CAEB) Graduate Attribute
1. Time Series Overview, Pre-processing, Visualisation, and Statistical and Machine Learning Analysis At the end of this section, students will be able to: a. Define time series types, characteristics, trend and seasonality, and challenges. b. Define preprocessing techniques for handling missing data, normalization, noise reduction and applying rolling window both in words and mathematically. c. Understanding and identifying autocorrelation d. Define different time series analysis (forecasting, classification, and anomaly detection). e. Statistical models for time series (ARIMA, SARIMA), their advantages and disadvantages. f. Feature engineering for time series and define concepts such as lag features, rolling statistics, and time-based features both in words and mathematically g. Machine learning for time series analysis h. Implement these methods in Python.	EE4, D1, **D2, D3, KB3, KB4, PA2, PA3, ET2, ET3**
2. Deep Learning and Neural Networks At the end of this section, students will be able to: a. Define in words and mathematically deep learning and its differences versus machine learning and statistical techniques. b. Define in words and mathematically deep neural networks, their learning process and categories c. Define in words and mathematically data splitting techniques (for different types of time series),	EE4, D1, **D2, D3, KB3, KB4, PA2, PA3, ET2, ET3**

optimization and loss functions, validation, and evaluation of deep learning models. d. Implement model training/validation/test e. Define in words and mathematically the signs of overfitting and methodologies to address that (regularization, dropout). f. Define in words and mathematically the signs of bias and methodologies to address that. g. List various applications of these models.	
3. Convolutional Neural Networks (CNNs) for Time Series At the end of this section, students will be able to: a. Define in words and mathematically the 1D CNN and TCN architectures b. Analyze time series using these architectures (Classification and Forecasting) c. Implement these architectures in train/validation/test steps d. Define their pros/cons versus other deep learning techniques for time series applications	EE4, D1, **D2, D3, KB3, KB4, PA2, PA3, ET2, ET3**
4. Recurrent Neural Networks (RNNs) At the end of this section, students will be able to: a. Define in words and mathematically the RNN model architecture and its variants (LSTM, GRU) b. Analyze time series using these architectures c. Implement these architectures in train/validation/test steps d. Define their pros/cons versus other deep learning techniques for time series applications	EE4, D1, **D2, D3, KB3, KB4, PA2, PA3, ET2, ET3**
5. Transformers At the end of this section, students will be able to: a. Define in words and mathematically concept of attention mechanism in deep learning b. Define in words and mathematically transformer architectures c. Define in words and mathematically applications of attention in time series forecasting d. Analyze time series using these architectures e. Implement these architectures in train/validation/test steps f. Define their pros/cons versus other deep learning techniques for time series applications.	EE4, D1, **D2, D3, KB3, KB4, PA2, PA3, ET2, ET3**

6. Autoencoders for Anomaly Detection At the end of this section, students will be able to: a. Define in words and mathematically time series anomalies b. Define in words and mathematically autoencoder structure c. Define in words and mathematically reconstruct time series and detect anomalies d. Implement these algorithms in practical examples in various domains	EE4, D1, **D2, D3, KB3, KB4, PA2, PA3, ET2, ET3**
7. Probabilistic Forecasting, Uncertainty, Fairness, and Hyperparameter Optimization At the end of this section, students will be able to: a. Explain probabilistic forecasting methods and distinguish aleatoric vs epistemic uncertainty. b. Implement models that provide uncertainty estimates. c. Identify fairness issues in time series and apply mitigation strategies. d. Compare and apply hyperparameter optimization methods (grid search, Bayesian, Hyperband, ASHA). e. Evaluate trade-offs between accuracy and computational cost in real-world applications.	EE4, D1, **D2, D3, KB3, KB4, PA2, PA3, ET2, ET3**
8. Advanced Representations and Hybrid Approaches At the end of this section, students will be able to: a. Transform time series into alternative domains (spectrograms) and apply deep learning models. b. Combine classical models with deep learning for noisy or irregular data. c. Assess advantages and limitations of hybrid and representation-based approaches.	EE4, D1, **D2, D3, KB3, KB4, PA2, PA3, ET2, ET3**
9. Generative AI for Time Series At the end of this section, students will be able to: a. Define generative modelling and distinguish generative models from discriminative models. b. Describe the principles and architectures of selected generative deep learning models, including Variational Autoencoders (VAEs) and Generative Adversarial Networks (GANs). c. Describe recent generative and foundation models for time-series data and their applications. d. Apply generative AI methods to time-series tasks such as synthetic data generation and forecasting. e. Implement and evaluate selected generative AI approaches for time-series data using Python.	EE4, D1, **D2, D3, KB3, KB4, PA2, PA3, ET2, ET3**

EVALUATION:

Assessment Type	Weight	CEAB GAs ASSESSED
Laboratory Assignments	15%	EE4, D1, **D2, D3, KB3, KB4, PA2, PA3, ET2, ET3**
Group Project (three in-lab phases + final report + code repository)	45%	EE4, D1, **D2, D3, KB3, KB4, PA2, PA3, ET2, ET3**
Quizzes	5%	EE4, D1, **D2, KB3, KB4, PA2, PA3, ET2**
Final Examination	35%	EE4, D1, **D2, D3, KB3, KB4, PA2, PA3, ET2, ET3**

Marks for laboratory assignments and project demonstrations will be based on correct implementation, appropriateness of methodology, analysis and interpretation of results, and demonstrated understanding of the work. Live questions or small code modifications may be used to assess individual understanding.

To obtain a passing grade in the course, a mark of 50% or more must be achieved on the final examination as well as on the laboratory assignments. A final examination or laboratory assignment mark < 50% will result in a final course grade of 48% or less.

COURSE POLICIES:

Laboratory Assignments: There will be six/seven in-lab group laboratory assignments during the term. Laboratory assignments are designed to provide progressive hands-on experience with the complete time-series modelling workflow. Students will work in groups of four within their registered laboratory section. Each laboratory assignment will be completed primarily during the scheduled laboratory period using Python and relevant machine/deep learning libraries. Students will normally receive a Jupyter notebook containing instructions, starter code, and selected hints. Students are expected to complete the required implementation, experiments, and analysis during the laboratory session. Full solution notebooks will be released after the corresponding laboratory assessment has been completed. Laboratory assignments will be assessed through an in-lab demonstration/check-off. Although the laboratory work is completed in groups, the TA/Instructor may question individual group members. Therefore, individual students within the same group may receive different grades if their demonstrated understanding differs. **The laboratory assignment with the lowest grade will be dropped for every student. Therefore, no late laboratory assignments will be accepted, and special accommodation for missed laboratory assignments will be denied**. A grade of 50% or higher on the laboratory assignments is required to pass the course.

Quizzes: Each student will need a laptop to complete the **in-person** quizzes. Three pop quizzes will be conducted during randomly selected classes throughout the semester. A quiz may include a concept as well as a practical component. **The lowest quiz mark will be dropped for every student. Therefore, special accommodation for missed quizzes will be denied**.

Group Project: The course project provides students with hands-on experience in developing and evaluating deep learning methods for a real-world time-series problem. Students will work in groups of four within the same laboratory section (**the same groups used for the laboratory assignments**). Each group will select one dataset from a collection of approved open-access time-series datasets provided by the instructor. The project will be developed incrementally throughout the semester. After each laboratory tutorial, groups are expected to apply the corresponding methods to their own project dataset. Thus, the project will evolve alongside the course material and three laboratory sessions are dedicated entirely to three project-phase demonstrations. The project is worth 45% of the final course grade and consists of the following four components:

- Phase 1 – Data, Baselines & Initial Deep Models, 5%
- Phase 2 - Architecture Comparison, HPO & Model Selection, 10%
- Phase 3 - Final System & Advanced Analysis,15%
- Final Report + Code Repository, (14% + 1%)

The full specification of the project will be provided on OWL.

Project Phases Demo and Code Repository Submission: The project code must be written in Python. The GitHub repository of the project's code must contain the code required to reproduce the experiments and final results, along with appropriate documentation and execution instructions, and must be submitted and shared with the course Instructor and TAs (Due: Dec 9, 2026 @11:59 PM). Groups are expected to demonstrate the project at three phases, including the code, outputs, figures, experiments and results directly from their development environment. The **TA/Instructor may ask questions of any individual group member** and may request a small live modification, explanation, or rerun of part of the project. Individual students within the same group may therefore receive different grades if their demonstrated understanding differs. All students in each project group are expected to attend each scheduled project-phase demonstration. Students who miss the lab for the demo will be graded 0 for the Project Demo. Approved absences will be handled in accordance with the Faculty of Engineering Academic Consideration policy.

"Please note that because the submission deadline for code repository of the project already includes flexibility in the form of a 48-hour submission window, the instructor reserves the right to deny academic consideration for submissions following the end of the period of flexibility."

Project Final Report: Each group will submit a final technical report of approximately **four pages in IEEE-style double-column format** (Due: Dec 9, 2026 @11:59 PM). The report should concisely describe the problem and dataset, modelling methodology, experiments, model comparison, hyperparameter optimization, final results, advanced analysis, a brief discussion of model reliability, uncertainty and conditions under which the model may fail, limitations and conclusions.

"Please note that because the submission deadline already includes flexibility in the form of a 48-hour submission window, the instructor reserves the right to deny academic consideration for submissions following the end of the period of flexibility."

Final Examination: The final exam date will be scheduled by the Office of the Registrar. The final exam will be in-person, in "**closed-book**" structures, and cover concepts from the entire course.

Each student may bring one (1) 8.5" by 11" or A4 sheet of paper into the final exam as a "cheat sheet". A grade of 50% or higher on the final examination is required to pass the course.

Late Submission Policy: No late submissions will be accepted; late submissions will be graded with 0%.

Use of English: In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work (except examinations) may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Attendance: Attendance is mandatory for all lectures and labs. Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the department, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

ABSENCE FROM MANDATORY COURSE COMMITMENTS: Students must familiarize themselves with the Policy on **Academic Consideration for Absences:**

https://www.eng.uwo.ca/undergraduate/academic-consideration-for-absences.html

I. Missed/Late Accommodation Policy

1. Students missing an examination will report the absence by submitting Academic Consideration Request form through STUDENT ABSENCE PORTAL.
2. Documentation must be provided as soon as possible.
3. Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence.

II. Exam Accommodation

1. If you are unable to write a final examination, report your absence using the Academic Consideration Request Form through STUDENT ABSENCE PORTAL.
2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). **The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, headache, sleeping in, misreading timetable and travel arrangements.**
3. In order to receive permission to write a Special Examination, you must obtain the approval of the Chair of the Department and the Associate Dean and in order to apply you must submit an the Academic Consideration Request Form through STUDENT ABSENCE PORTAL.
   PLEASE NOTE: It is the student's responsibility to check the date, time and location of the Special Examination.

III. Medical Accommodation

1. Requests for Academic Consideration Request Form through STUDENT ABSENCE PORTAL.

2. Requests for academic consideration must include the following components:
    a. Self-attestation signed by the student (*This is only accepted for the first/one absence*)
    b. Medical note. Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence.
    c. Indication of the course(s) and assessment(s) affected by the request
    d. Supporting documentation as relevant
3. Requests without supporting documentation are limited to one per term per course.
4. **Students must request academic consideration as soon as possible and no later than 48 hours after the missed assessment.**
5. Once the request and supporting documents have been received and reviewed, appropriate academic consideration, if granted, shall be determined by the instructor in consultation with the academic advisor, in a manner consistent with the course outline.
   Academic consideration may include extension of deadlines, waiver of attendance requirements for classes/labs/tutorials, or re-weighting of course requirements. Some forms of academic consideration, such as arranging Special Examinations, assigning a grade of Incomplete, or granting late withdrawals without academic penalty, may only be granted by the Academic Advising office of the Faculty of Registration.

IV. Religious Accommodation

When scheduling unavoidably conflicts with religious holidays, which (a) require an absence from the University or (b) prohibit or require certain activities (i.e., activities that would make it impossible for the student to satisfy the academic requirements scheduled on the day(s) involved), no student will be penalized for absence because of religious reasons, and alternative means will be sought for satisfying the academic requirements involved. If a suitable arrangement cannot be worked out between the student and instructor involved, they should consult the appropriate Department Chair and, if necessary, the student's Dean.

It is the responsibility of such students to inform themselves concerning the work done in classes from which they are absent and to take appropriate action.

V. Academic Integrity

In the Faculty of Engineering, we encourage students to create a culture of honesty, trust, fairness, respect, responsibility, and courage, befitting the professional degree you are pursuing.

Please visit Academic Integrity Western Engineering for more information

VI. Academic Offences

Plagiarism means using another's work without giving credit. The university has rules against plagiarism and other scholastic offences. Western Engineering has a zero-tolerance policy on plagiarism. The minimum penalty is zero on the course work and a repeat offence will earn you zero on the course. A third offence may lead to expulsion from the university.

Scholastic Discipline for Undergraduate Students & Cheating, Plagiarism and Unauthorized Collaboration: What Students Need to Know

Students must write their reports, essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission

of a scholastic offence is attended by academic penalties, which might include expulsion from the program. If you are caught cheating, there will be no second warning.

All required papers may be subject to submission for textual similarity review to commercial plagiarism detection software under license to the University for the detection of plagiarism. All papers submitted will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (http://www.turnitin.com). Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, in the relevant section of the Academic Handbook:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

VII. Faculty of Engineering AI Policy

The use of generative Artificial intelligence (GenAI) tools won't be discouraged in the Faculty of Engineering. As we pride ourselves on building the future we can't hide from the use of GenAI tools to contribute to the understanding of the course materials. However, the use of GenAI tools in any assignment or contribution during the course will have to be disclosed, as a resource.

GenAI tools use won't be permitted in any type of examination or other assessments where the faculty have prohibited their use. If use of GenAI tools is detected by the instructor in these instances, academic offences penalties might be imposed against the student.

VIII. Use of English Policy

In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work except for the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

IX. Accessibility

Western is committed to achieving barrier free accessibility for persons with disabilities studying, visiting and working at Western. As part of this commitment, there are a variety of services, groups and committees on campus devoted to promoting accessibility and to ensuring that individuals have equitable access to services and facilities. To help provide the best experience to all members of the campus community, please visit the Accessibility Western University for information on accessibility-related resources available at Western.

Students with disabilities may arrange for academic accommodation at Western. For a more detailed explanation, please visit Academic Support & Engagement -Academic Accommodation.

X. Inclusivity, Diversity, and Respect

The Faculty of Engineering at Western University is committed to creating equitable and inclusive learning environments that value diverse perspectives and experiences. We recognize that university courses often marginalize students based on social identity characteristics such as, but not limited to, Indigeneity, race, ethnicity, nationality, ability, gender identity, gender expression, sexuality, age, language, religion, and socioeconomic status. Understanding this, we strive to facilitate equitable experiences and inclusion within the classroom by respecting and integrating multiple ways of knowing, being, and doing. Please visit the Office of Equity, Diversity and Inclusion.

XI. Health and Well-Being

- Health & Wellness Services – Students - Offers appointment-based medical clinic for all registered part-time and full-time students.

- Mental Health Support - Provides professional and confidential services, free of charge, to students needing assistance to meet their personal, social and academic goals. Services include consultation, referral, groups and workshops, as well as brief, change-oriented psychotherapy.
- Crisis Support - For immediate assistant, please visit Thames Hall Room 2170 or call 519-661-3030. The crisis clinic operates between 11:00 am - 4:30 pm. For after-hours crisis support, click here.
- Gender-Based Violence and Survivor Support - Western is committed to reducing incidents of gender-based and sexual violence and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced gender-based or sexual violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts, here. To connect with a case manager or set up an appointment, please contact support@uwo.ca.

Important Contacts

Engineering Undergraduate Services
Electrical and Computer Engineering

Office of the Registrar/Student Central

Important Links

- WESTERN ACADEMIC CALENDAR
- ACADEMIC RIGHTS AND RESPONSIBILITIES
- ENGINEERING PROGRESSION REQUIREMENTS AND ACADEMIC REGULATIONS
- UNIVERSITY STUDENTS' COUNCIL (USC) - SERVICES
- IMPORTANT DATES AND DEADLINES
- ACADEMIC CONSIDERATION FOR MEDICAL ILLNESS - UNDERGRADUATE STUDENTS
- ACCOMMODATIONS FOR RELIGIOUS HOLIDAYS
- SCHEDULING OF ASSIGNMENTS, TESTS, AND EXAMINATIONS
- STUDENT FORMS
- OFFICE OF THE REGISTRAR
- RETENTION OF ELECTRONIC VERSION OF COURSE OUTLINES (SYLLABI)
- ACADEMIC APPEALS
- STUDENT ABSENCE PORTAL