Western University
Faculty of Engineering
Department of Civil and Environmental Engineering

CEE 9414 - Data Management and Applications in Smart Cities
Course Outline – Summer 2025

DESCRIPTION

This course is designed to provide a comprehensive overview of data management techniques and technologies relevant to Smart Cities and focusing on Civil and Environmental Engineering applications such as transportation and urban infrastructure. Students will explore the role of data in enhancing urban planning and decision-making processes, learning essential coding and data analysis skills. Through hands-on projects, collaborative learning, and interactive discussions, they will engage with real-world scenarios demonstrating the importance of data-driven solutions in urban environments. The course activities include relevant smart cities data management projects and readings of the latest research papers on data management and its applications in smart cities. By the end of the course, students will have a solid understanding of the core concepts related to data management in smart city contexts, reinforced by case studies, expert seminars, group projects, and course assignments.

ENROLLMENT RESTRICTIONS

Enrollment in this course is open to graduate students with bachelor's degree in Civil and Environmental Engineering or similar, as well as any student who has obtained permission to enroll in this course from the course instructor and/or the Graduate Chair (or equivalent) from the student's home program.

PREREQUISITE

None

INSTRUCTOR CONTACT INFORMATION

- Course instructor: Dr. Mohamed Zaki
- Email address: mzaki9@uwo.ca
- Lecture hours: 36 Contact hours
- Office hours: Weekly office hours will be held either in person or via Zoom by appointment
- *Administrative Support*: PhD and MESc students: ceeresearchgrad@uwo.ca
  MEng students: ceeprofessionalgrad@uwo.ca

COURSE FORMAT

This course will be delivered **in-person**.

"In the event of a COVID-19 resurgence during the course that necessitates the course delivery

moving away from face-to-face interaction, all remaining course content will be delivered entirely online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will not change. Any remaining assessments will also be conducted online at the discretion of the course instructor"

TOPICS

Topic #	Description	Learning Activities	Tentative timeline
1	**Introduction**		
	Lesson 1: Present Course Syllabus, course expectations, Introduction to Smart Cities and Data Needs and Challenges Overview of smart city concepts, significance, and technology in urban infrastructure development	Lecture 1: 3-hour class Reading material (**TBD**) Overview of smart city concepts, significance, and technology in urban infrastructure development	Week 1
2	**Data Management Fundamentals for Smart Cities**		
	Lesson 2: Introduction to data management principles, structures, Knowledge Discovery in Databases (KDD), and terminology specific to civil engineering and smart cities	Lecture 2: 3-hour class Reading material (**TBD**) In-class exercises on terminology and key terms and concepts	Week 1
	Lesson 3: Civil Engineering Data Modeling and Databases using Structured Query Language (SQL) Learn how to model urban infrastructure data requirements using Entity-Relationship Modeling (ER) diagrams. Review SQL key concepts	Lecture 3: 3-hour class Reading material (**TBD**) Assignment 1 (Due) In-class exercises: Prototype an ER model for an urban traffic management system.	Week 2
	Lesson 4: Understanding the relational model and its application in managing urban datasets. Review SQL key concepts (Continue)	Lecture 4: 3-hour class Reading material (**TBD**) In-class exercises: Design a relational database schema based on the ER model created.	Week 2
	Lesson 5: Select Topics in Data Management Normalization and Data Integration Explore the principles of normalization for database integrity and efficiency.	Lecture 5: 3-hour class Reading material (**TBD**) Assignment 2 (Due) In-class exercises: SQL	Week 3

	Learn techniques for integrating data from multiple sources to create a cohesive urban data ecosystem.	Challenge	
	Lesson 6: Quiz Overview basic Data Warehousing Concepts	Lecture 6: 3-hour class In Class Quiz	Week 3
3	**Research Paper Presentations**		
	Lesson 7: Students will present and discuss research papers	Students presentations Lecture 7: 3-hour class	Week 4
4	**Data Mining in Urban Context**		
	Lesson 8: Introduction to data mining techniques and their applications in analyzing urban infrastructure. Smart Technologies in Civil Engineering	Lecture 8: 3-hour class In-class exercises Assignment 3 (Due) **Group Discussion**: Evaluate the benefits and limitations of smart technologies (e.g., Internet of Things, Edge Computing, GIS) in civil engineering projects.	Week 4
	Lesson 9: Continue data mining techniques for smart cities applications	Lecture 9: 3-hour class In-class exercises Assignment 4 (Due) **Group Discussion**: Evaluate the benefits and limitations of smart technologies (e.g., Internet of Things, Edge Computing, GIS) in civil engineering projects.	Week 5
	Lesson 10: Smart Cities Data Visualization Techniques	Lectures 10: 3-hour class reading material (**TBD**) **Group In Class Exercise**: Create visualization templates using data analysis results from previous assignments.	Week 5
	Lesson 11: Policy and Ethics in Smart Cities. Data Governance Framework and Security. Policies for	Lectures 11: 3-hour class	Week 6

	data access, quality, compliance	reading material (**TBD**) Assignment 5 (Due) **In In-class discussion**: Discuss varying perspectives on data privacy issues in smart cities.	
5	**Review**		
	Lesson 12: Final Project Group Presentations.	Lectures 12: 3-hour class Reading material (**TBD**) **Presentation**: Each group presents findings, insights, and recommendations with Q&A session.	Week 6

SPECIFIC LEARNING OUTCOMES

Degree Level Expectation	**Weight**	**Assessment Tools**	**Outcomes**
Depth and breadth of knowledge	30%	- Assignments - Quiz - Final exam - Project	- Understanding of advanced concepts and theories in data science and smart cities such as urban transportation infrastructure - Awareness of important current smart cities problems in data management and analysis - Understanding of database-related computational and/or empirical methodologies to solve smart cities related problems in data management
Research & scholarship	15%	- Paper Review - Project	- Ability to conduct critical evaluations of current advancements in data science for smart cities - Ability to conduct coherent and thorough analyses of complex smart cities data problems using established data management techniques/principles (data collection, integration and mining) and judgment

Application of knowledge	20%	- Assignments - Final exam - Project - Quiz	- Ability to apply data mining and data management knowledge in a rational way to analyze databases of particular smart cities problems - Ability to use coherent approach to design a data management system for smart cities applications using existing database tools
Professional capacity / autonomy	10%	- Project	- Awareness of academic integrity - Ability to implement established procedures and practices in the coursework - Defends own ideas and conclusions - Integrates reflection into his/her learning process
Communication skills	15%	- Paper review - Project	- Ability to communicate (oral and/or written) ideas, issues, results and conclusions clearly and effectively - Ability to create meaningful visualizations to communicate results of data analysis in smart cities
Awareness of limits of knowledge	10%	- Projects	- Awareness of the importance of assumptions in complex scientific analyses and their implications in smart cities - Understanding the difference between theoretical frameworks and empirical methodologies. - Recognition of analytical limitations due to complexities of practical smart cities problem.

COURSE MATERIAL

Prepared class notes will be made available through the course website on OWL at http://owl.uwo.ca/, along with other useful reference material and data for assignments.

Lecture notes and any posted demonstration videos are copyrighted to the instructor and legally protected. Do not post these videos and lecture notes on any other website or online forums. The recording of the live/synchronous lectures of the course without the permission from the course instructor is prohibited.The illegal posting and sharing of the copyrighted course content could be subjected to legal actions.

REFERENCES

No specific textbook will be needed. Course notes and handouts are the primary references used in this course. Resources will be posted on the course webpage. Other optional references are listed below:

Lake, P., Crowther, P. (2021). Concise Guide to Databases: A Practical Introduction. United Kingdom: Springer London. (Available online via Western Library)

Aalst, W. v. d. (2016). Process Mining: Data Science in Action. Germany: Springer Berlin Heidelberg. (Available online via Western Library)

ASSESSMENT

Assessment Type	Material Covered	Tentative Due Date*	Weight
Homework Assignments (Five in Total -Best of Four with 5% each) – Individual Work	Topics 1 - 4	Check course calendar	20%
Participation and Engagement – Individual or Group Work	In person and posted questions in course OWL site "Forums"	Weekly activity	5%
Final Project – Individual Work		Check course calendar	40%
Final Exam (Open Book) – Individual Work	Topics 1 - 4	Examination Period	20%
Research Paper Review and Presentation – Individual Work	Topic 1-4	Check course calendar	5%
Quiz (Open Book) – Individual Work	Topic 1, 2	Check course calendar	10%

* The shown dates are tentative and are subject to change.

Research Paper Review and Presentation

Short paper critique covering some of the main modules of the course will be required. The instructor will distribute papers directly for students for review and critique. The instructions and rubric will be posted on OWL. Due dates for this homework will be clearly announced in the first week of class. No late homework will be accepted. All assignments should be done neatly and professionally.

Assignments

The assignments will be posted on course OWL with the due date and time indicated. Each assignment must be submitted as a single PDF file through OWL. In case of programming assignments, the code files will also be uploaded. Except when explicitly specified, all assignments are to be completed individually. Students must write and program their own work. Copying homework from another student/group, or other sources is a violation of academic integrity (see below).

Final project and presentation

Students can choose to work individually or in a group of 3 maximum on a project relevant to the material taught in the class. Related software tools and data sets will be provided. A project grade will be divided between a proposal report, progress report, individual contribution and a final paper and presentation. Each group will work closely with the instructor in defining the project scope. Students are encouraged to come up with their ideas for the project. A presentation summarizing the efforts and the results will be scheduled before the final project report submission.

Instructions, formatting and rubric will be posted online through OWL. The breakdown of grades for the Final Project is as follows:

Item	**Breakdown**
Project proposal	5%
Project update report	5%
Teamwork and interaction (Team Journal Logs and minutes)	5%
End of Semester Presentation	10%
End of Semester Report	15%
Total	40%

Quiz and Final Exam

The quiz (1 hour) and the final exam (1 hour) will be open book and will comprise a combination of design questions, data-set, and short-answer questions. In the case the quiz is rescheduled, there will be an announcement at least eight days in advance of the new date. In the case of unexpected events that delay a quiz (e.g., COVID Lockdown, wide-spread power outage), the next available date will be selected.

A written open book final examination will be held during the regular examination period.

Activities in which collaboration is permitted:

- *Participation using course OWL site "Forums"*: Weekly forums will be posted on the course site OWL. Each week students are expected to interact with the course content and with each other by posting questions/responding to existing questions on OWL "Forums". Minimum expectation regarding this participation activity is at least one posting per week. Group discussion using "Forums" regarding course material and topics covered in lectures is permitted.
- *Final Project*: Students will be divided into groups (2 members per group). Collaboration between ***only*** group members is permitted. One final project report is required from each group.

Activities in which students must work alone (collaboration is not permitted):

- Homework Assignments
- Quiz
- Final Exam
- Research Paper Review and Presentation

UNITS

SI units will be used in lectures and examinations

CHEATING, PLAGIARISM/ACADEMIC OFFENCES

Academic integrity is an essential component of learning activities. Students must have a clear understanding of the course activities in which they are expected to work alone (and what working alone implies) and the activities in which they can collaborate or seek help; see information above and ask instructor for clarification if needed. Any unauthorized forms of help-seeking or collaboration will be considered an academic offense. University policy states that cheating is an academic offence. If you are caught cheating, there will be no second warning. Students must write their essays and assignments in their own words. Whenever students take an idea or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence. Academic offences are taken seriously and attended by academic penalties which may include expulsion from the program. Students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence at the following website:
https://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf

CONDUCT

Students are expected to follow proper etiquette to maintain an appropriate and respectful

academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in course activities and/or is not following the rules and responsibilities associated with the course activities, will be reported to the Associate Dean (Graduate) (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Associate Dean (Graduate), the student could be debarred from completing the assessment activities in the course as appropriate.

STATEMENT ON THE USE OF GENERATIVE ARTIFICIAL INTELLIGENCE (AI)

The use of AI in the preparation of the project and assignments must be acknowledged in the submission. Please refer to the published Provisional Guidance for the Use of Generative AI in Graduate Studies at Western University.

HEALTH/WELLNESS SERVICES

As part of a successful graduate student experience at Western, we encourage students to make their health and wellness a priority. Western provides several health and wellness related services to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. Information regarding health- and wellness-related services available to students may be found at http://www.health.uwo.ca/.

Students seeking help regarding mental health concerns are advised to speak to someone they feel comfortable confiding in, such as their faculty supervisor, their program director (graduate chair), or other relevant administrators in their unit. Faculty of Engineering has a Student Wellness Counsellor. Information on how to schedule an appointment with the counsellor is available at: https://www.eng.uwo.ca/undergraduate/academic-support-and-accommodations/Student-Wellness-Counselling.html

Students who are in emotional/mental distress should refer to Mental Health@Western: http://www.uwo.ca/uwocom/mentalhealth/ for a complete list of options about how to obtain help.

SICKNESS

Students should immediately consult with the instructor (for a particular course) or Associate Chair (Graduate) (for a range of courses) if they have problems that could affect their performance. The student should seek advice from the Instructor or Associate Chair (Graduate) regarding how best to deal with the problem. Failure to notify the Instructor or the Associate Chair (Graduate) immediately (or as soon as possible thereafter) will have a negative effect on any appeal. Obtaining appropriate documentation (e.g., a note from the doctor) is valuable when asking for accommodation due to illness.

Students who are not able to meet certain academic responsibilities due to medical, compassionate, or other legitimate reason(s), could request for academic consideration. The Graduate Academic Accommodation Policy and Procedure details are available at:
https://www.eng.uwo.ca/graduate/current-students/academic-support-and-

accommodations/index.html

STATEMENT ON GENDER-BASED AND SEXUAL VIOLENCE

Western is committed to reducing incidents of gender-based and sexual violence (GBSV) and providing compassionate support to anyone who is going through or has gone through these traumatic events. If you are experiencing or have experienced GBSV (either recently or in the past), you will find information about support services for survivors, including emergency contacts at the following website:
https://www.uwo.ca/health/student_support/survivor_support/get-help.html
To connect with a case manager or set up an appointment, please contact support@uwo.ca

ACCESSIBLE EDUCATION WESTERN (AEW)

Western is committed to achieving barrier-free accessibility for all its members, including graduate students. As part of this commitment, Western provides a variety of services devoted to promoting, advocating, and accommodating persons with disabilities in their respective graduate program.
Graduate students with disabilities (for example, chronic illnesses, mental health conditions, mobility impairments) are strongly encouraged to register with Accessible Education Western (AEW):
http://academicsupport.uwo.ca/accessible_education/index.html

AEW is a confidential service designed to support graduate and undergraduate students through their academic program. With the appropriate documentation, the student will work with both AEW and their graduate programs (normally their Graduate Chair and/or Course instructor) to ensure that appropriate academic accommodations to program requirements are arranged. These accommodations include individual counselling, alternative formatted literature, accessible campus transportation, learning strategy instruction, writing exams and assistive technology instruction.