

Course Outline (W2026)

COE818: Advanced Computer Architecture

Instructor(s)	Dr. Andy Ye [Coordinator] Office: ENG319 Phone: (416) 979-5000 x 554901 Email: agye@torontomu.ca Office Hours: Tuesdays 11:30am to 12:30pm
Calendar Description	The main topics include: instruction set architecture for advanced processor, advanced pipelining, including branch predication, instruction level parallelism. It also covers advanced architecture including superscalar VLIW, speculative, vector processors, multithreading and multi-processors. It discusses the performance limitations and scalability issues and introduces real-world examples including MMX technology, and Pentium architectures. The laboratory work includes performance evaluation of advanced architectures.
Prerequisites	COE 758
Antirequisites	None
Corerequisites	None
Compulsory Text(s):	<ol style="list-style-type: none"> 1. John L. Hennessy and David A. Patterson, "Computer Architecture: A Quantitative Approach," 6th Edition, 2019, Morgan Kaufmann Publishers, Cambridge, MA, ISBN: 978-0-12-811905-1 2. Laboratory Manual: Available through D2L and http://www.ee.ryerson.ca/~courses/ele818
Reference Text(s):	
Learning Objectives (Indicators)	<p>At the end of this course, the successful student will be able to:</p> <ol style="list-style-type: none"> 1. Uses numerical and analytical models to predict, control, and design component, system. (1b) 2. Identifies potential hazards and checks for alternative solutions. (2a) 3. Compares model predictions with real-world data Proposes model improvements (2b) 4. Appraises the validity/reliability of data relative to the degrees of error and limitations of theory and measurement (3a) 5. Anticipates the needs of the project, customizes design processes, analyzes progress, and revises plans as necessary. Uses strategic planning in more complex design problems/systems. (4a) 6. Uses strategic planning in more complex design problems/systems. (4c) 7. Generates solutions for more complex design engineering problems/systems. (4b) 8. Designs and develops simple tools (software, hardware) to perform given tasks as required by the project. (5a) <p>NOTE:Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).</p>

Course Organization	3.0 hours of lecture per week for 13 weeks 1.0 hours of lab per week for 12 weeks 0.0 hours of tutorial per week for 12 weeks												
Teaching Assistants	Divya Bharathi Kannappan, divya.kannappan@torontomu.ca, 012-LAB 092-LAB 022-LAB Harkartik Singh, harkartik.singh@torontomu.ca, 042-LAB 032-LAB 052-LAB Karan Hayer, karan.hayer@torontomu.ca, 082-LAB 072-LAB 062-LAB												
Course Evaluation	<table border="1"> <thead> <tr> <th colspan="2">Theory</th> </tr> </thead> <tbody> <tr> <td>Midterm Exam</td> <td>25 %</td> </tr> <tr> <td>Final EXam</td> <td>50 %</td> </tr> <tr> <th colspan="2">Laboratory</th> </tr> <tr> <td>Lab Reports</td> <td>25 %</td> </tr> <tr> <td>TOTAL:</td> <td>100 %</td> </tr> </tbody> </table> <p>Note: In order for a student to pass a course, a minimum overall course mark of 50% must be obtained. In addition, for courses that have both "Theory and Laboratory" components, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the "Course Evaluation" section above for details on the Theory and Laboratory components (if applicable).</p>	Theory		Midterm Exam	25 %	Final EXam	50 %	Laboratory		Lab Reports	25 %	TOTAL:	100 %
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Examinations	Midterm exam in Week 7, for two hours, closed book (covers Weeks 1-6). Final exam, during the exam period, two and half hours, closed-book (covers Weeks 1-13).												
Other Evaluation Information	Use of Generative AI (e.g. ChatGPT, Grammarly, Perplexity, DeepL Translator) to develop or assist with any ideas or material submitted for coursework is expressly prohibited in this course. Use of Generative AI in this manner will be considered a breach of Policy 60.												
Teaching Methods	Lecture time Mondays from 12pm to 3pm DCC208												
Other Information	None												

Course Content

Week	Hours	Chapters / Section	Topic, description
1 (Jan 5 - 11)	3	A.1 - A.5	Instruction Set Principles <ul style="list-style-type: none"> - Review and Introduction - Classifying Instruction Set Architecture - Memory Addressing

			<ul style="list-style-type: none"> - Type and Size of Operands - Operations in the Instruction Set
2 (Jan 12 - 18)	3	A.6 - A.9	<p>Instruction Set Principles</p> <ul style="list-style-type: none"> - Instructions for Control Flow - Encoding an Instruction Set - The Role of Compilers - The RISC-V Architecture
3 (Jan 19 - 25)	3	C.1 - C.2	<p>Pipelining Basic and Intermediate Concepts</p> <ul style="list-style-type: none"> - Introduction - Pipeline Hazards
4 (Jan 26 - 1)	3	C.3 - C.4	<p>Pipelining Basic and Intermediate Concepts</p> <ul style="list-style-type: none"> - How is Pipelining Implemented? - What Makes Pipelining Hard to Implement?
5 (Feb 2 - 8)	3	C.5 - C.6	<p>Pipelining Basic and Intermediate Concepts</p> <ul style="list-style-type: none"> - Extending the RISC V Integer Pipeline to Handle Multicycle Operations - The MIPS R4000 Pipeline
6 (Feb 9 - 15)	3	3.1 - 3.4	<p>Instruction-Level Parallelism:</p> <ul style="list-style-type: none"> - Instruction-Level Parallelism: Concept and Challenges - Basic Compiler Level Techniques for Exposing ILP - Reducing Branch Costs With Advanced Branch Prediction - Overcoming Data Hazards With Dynamic Scheduling
(Feb 16 - 22)	3		Reading Week
7 (Feb 23 - 1)	3		Midterm (90 minutes, Feb 23, in class)
8 (Mar 2 - 8)	3	3.5 - 3.8	<p>Instruction-Level Parallelism:</p> <ul style="list-style-type: none"> - Dynamic Scheduling: Examples and the Algorithm - Hardware-Based Speculation - Exploiting ILP Using Multiple Issue and Static Scheduling - Exploiting ILP Using Dynamic Scheduling, Multiple Issue, and Speculation

9 (Mar 9 - 15)	3	3.9 - 3.12	<p>Instruction-Level Parallelism:</p> <ul style="list-style-type: none"> - Advanced Techniques for Instruction Delivery and Speculation - Cross-Cutting Issues - Multi-threading: Exploiting Thread-Level Parallelism to Improve Uniprocessor Throughput - The Intel Core i7 6700 and ARM Cortex-A53
10 (Mar 16 - 22)	3	4.1 - 4.3	<p>Data-Level Parallelism in Vector, SIMD, and GPU Architectures</p> <ul style="list-style-type: none"> - Introduction - Vector Architecture - SIMD Instruction Set Extensions for Multimedia
11 (Mar 23 - 29)	3	4.4 - 4.7	<p>Data-Level Parallelism in Vector, SIMD, and GPU Architectures</p> <ul style="list-style-type: none"> - Graphics Processing Units - Detecting and Enhancing Loop-Level Parallelism - Cross-Cutting Issues - Embedded Versus Server GPUs and Tesla Versus Core i7
12 (Mar 30 - 5)	3	5.1 - 5.4	<p>Thread-Level Parallelism</p> <ul style="list-style-type: none"> - Introduction - Centralized Shared-Memory Architectures - Performance of Symmetric Shared-Memory Multiprocessors - Distributed Shared-Memory and Directory-Based Coherence
13 (Apr 6 - 12)	3	5.5 - 5.8	<p>Thread-Level Parallelism</p> <ul style="list-style-type: none"> - Synchronization: The Basics - Models of Memory Consistency: An Introduction - Cross-Cutting Issues - Putting It All Together: Multicore Processors and Their Performance

Laboratory(L)/Tutorials(T)/Activity(A) Schedule

Week	L/T/A	Description
2-3	ENG412	Using SIMPLESALAR Simulator
4	ENG412	Evaluating Performance of Computer System
5-9	ENG412	Using NVIDIA GPU Part 1

10-12	ENG412	Using NVIDIA GPU Part 2
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University Policies & Important Information

Students are reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on [the Senate website](#)

Refer to the [Departmental FAQ page](#) for further information on common questions.

Important Resources Available at Toronto Metropolitan University

- [The University Libraries](#) provide research [workshops](#) and individual consultation appointments. There is a drop-in Research Help desk on the second floor of the library, and students can use the [Library's virtual research help service](#) to speak with a librarian, or [book an appointment](#) to meet in person or online.
- [Student Life and Learning Support](#) offers group-based and individual help with writing, math, study skills, and transition support, as well as [resources and checklists to support students as online learners](#).
- You can submit an [Academic Consideration Request](#) when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill an academic requirement. You may always visit the [Senate website](#) and select the blue radio button on the top right hand side entitled: Academic Consideration Request (ACR) to submit this request.

For Extenuating Circumstances, [Policy 167: Academic Consideration](#) allows for a once per semester ACR request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. Absences more than 3 days in duration and those that involve a final exam/final assessment, always require documentation. Students must notify their faculty/contract lecturer once a request for academic consideration is submitted. See Senate [Policy 167: Academic Consideration](#).

Longer absences are not addressed through Policy 167 and should be discussed with your Chair/Director/Program to be advised on next steps.

- [FAQs Academic Considerations and Appeals](#)
- Information on Copyright for [Faculty/Contract Lecturers](#) and [students](#).

Lab Safety (if applicable)

Students are to strictly adhere and follow:

- a. The Lab Safety information/guidelines posted in the respective labs,
- b. provided in their respective lab handouts, and
- c. instructions provided by the Teaching Assistants/Course instructors/Technical Staff.

During the lab sessions, to avoid tripping hazards, the area around the lab stations should not be surrounded by bags, backpacks etc, students should place their bags, backpacks etc against the walls of the labs and/or away from their lab stations in such a way that it avoids tripping hazards.

Accessibility

- Similar to an [accessibility statement](#), use this section to describe your commitment to making this course accessible to students with disabilities. Improving the accessibility of your course helps minimize the need for accommodation.
- Outline any technologies used in this course and any known accessibility features or barriers (if applicable).
- Describe how a student should contact you if they discover an accessibility barrier with any course materials or technologies.

Academic Accommodation Support

Academic Accommodation Support (AAS) is the university's disability services office. AAS works directly with incoming and returning students looking for help with their academic accommodations. AAS works with any student who requires academic accommodation regardless of program or course load.

- Learn more about [Academic Accommodation Support](#).
- Learn [how to register with AAS](#).
- Learn about [Policy 159: Academic Accommodation of Students with Disabilities](#)

Academic Accommodations (for students with disabilities) and Academic Consideration (for students faced with extenuating circumstances that can include short-term health issues) are governed by two different university policies. Learn more about [Academic Accommodations versus Academic Consideration and how to access each](#).

Wellbeing Support

At Toronto Metropolitan University, we recognize that things can come up throughout the term that may interfere with a student's ability to succeed in their coursework. These circumstances are outside of one's control and can have a serious impact on physical and mental well-being. Seeking help can be a challenge, especially in those times of crisis.

If you are experiencing a mental health crisis, please call 911 and go to the nearest hospital emergency room. You can also access these outside resources at anytime:

- **Distress Line:** 24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
- **Good2Talk:** 24/7-hour line for postsecondary students (phone: 1-866-925-5454)
- **Keep.meSAFE:** 24/7 access to confidential support through counsellors via [My SSP app](#) or 1-844-451-9700

If non-crisis support is needed, you can access these campus resources:

- **Centre for Student Development and Counselling:** 416-979-5195 or email csdc@torontomu.ca
- **Consent Comes First - Office of Sexual Violence Support and Education:** 416-919-5000 ext 3596 or email osvse@torontomu.ca
- **Medical Centre:** call (416) 979-5070 to book an appointment

We encourage all Toronto Metropolitan University community members to access available resources to ensure support is reachable. You can find more resources available through the [Toronto Metropolitan University Mental Health and Wellbeing](#) website.