ENGG*4540 Advanced Computer Architecture

Winter 2019
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - January 05, 2019

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1 Course Details

1.1 Calendar Description

This course covers topics such as: basics of pipeline structure, advanced pipelining and instruction level parallelism, multiprocessor and thread-level parallelism, memory-hierarchy design (main memory, virtual memory, caches), storage systems, interconnection networks, multiprocessor architectures (centralized and distributed). Advanced topics related to new emerging computer architectures will also be presented. The emphasis in each topic is on fundamental limitations and the trade-offs involved in designing computer systems, including memory and processing bandwidth, network bandwidth and latency, synchronization, and storage system bandwidth and latency.

Pre-Requisite(s): ENGG*3380

1.2 Course Description

The aim of this course is to familiarize students with the basic principles of computer architecture and design, with an emphasis on cost-performance-energy trade-offs, good engineering design, and a focus on quantitative analysis of real systems.

1.3 Timetable

Lectures

Monday 11:30 am – 12:50 pm MCKN 235
Wednesday 11:30 pm – 12:50 pm MCKN 235

Lab sessions

Friday 11:30AM - 01:20PM RICH 1532

Friday 11:30AM - 01:20PM RICH 2531

1.4 Final Exam

Friday April 12, 2019, 11:30AM - 01:30PM. Room TBA.

Exam time and location is subject to change. Please see WebAdvisor for the latest information.

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2 Instructional Support

2.1 Instructional Support Team

Instructor: Mohamed Hassan Ph.D.
Email: mohassan@uoguelph.ca

2.2 Teaching Assistant(s)

Teaching Assistant: Baucas Marc Jayson
Email: baucas@uoguelph.ca

2.3 Lab Technician

Matthew Saunders

Email:

msaund05@uoguelph.ca

Phone number:

519-824-4120 ext: 53916

Office:

Room 1506

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3 Learning Resources

3.1 Required Resource(s)

Course Website (Website)
Course material, news, announcements, and grades will be regularly posted to the ENGG*4540 CourseLink. You are responsible for checking the site regularly.

Computer Architecture: A Quantitative Approach (Textbook)
John L. Hennessy and David A. Patterson, 5th Edition, Morgan Kaufmann

3.2 Additional Resource(s)

Additional Resources (Other)

Lecture Information: Selected lecture notes are posted on the ENGG*4540 CourseLink system

Lab Information: The Lab Manual will be posted on the ENGG*4540 CourseLink system

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4 Learning Outcomes

4.1 Course Learning Outcomes

By the end of this course, you should be able to:

1. Identify the tasks involved in computer architecture design, with trends in technology, usage, and cost
2. Measure and report performance of computer architectures
3. Classify instruction set architectures, and comprehend the instruction formats and semantics
4. Identify and analyze basic pipeline operations, data and control pipeline hazards, and instruction- level parallelism
5. Communicate effectively about advanced computer architectures and memory-hierarchy design, including cache design issues and modern multicore architectures
6. Experiment with computer architecture simulators to investigate different design choices and study the impact of each of these choices.

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome(s)
1	Knowledge Base	2, 3, 4, 5
1.3	Recall, describe and apply fundamental engineering principles and concepts	2, 3, 4, 5
1.4	Recall, describe and apply program-specific engineering principles and concepts	3
2	Problem Analysis	2, 3, 4, 5, 6
2.1	Formulate a problem statement in engineering and non-engineering	2, 3, 4, 5, 6

#	Outcome	Learning Outcome(s)
	terminology	
2.2	Identify, organize and justify appropriate information, including assumptions	2, 3, 4, 5, 6
2.3	Construct a conceptual framework and select an appropriate solution approach	2, 3, 4, 5, 6
2.4	Execute an engineering solution	2, 3, 4, 5, 6
2.5	Critique and appraise solution approach and results	2, 3, 4, 5, 6
3	Investigation	6
3.1	Propose a working hypothesis	6
3.2	Design and apply an experimental plan/investigative approach (for example, to characterize, test or troubleshoot a system)	6
3.3	Analyze and interpret experimental data	6
3.4	Assess validity of conclusions within limitations of data and methodologies	6
4	Design	1, 5, 6
4.1	Describe design process used to develop design solution	6
4.2	Construct design-specific problem statements including the definition of criteria and constraints	1, 6
4.3	Create a variety of engineering design solutions	6
4.4	Evaluate alternative design solutions based on problem definition	1, 5, 6
4.5	Develop and refine an engineering design solution, through techniques such as iteration, simulation and/or prototyping	6
5	Use of Engineering Tools	6
5.1	Select appropriate engineering tools from various alternatives	6
5.2	Demonstrate proficiency in the application of selected engineering tools	6
5.3	Recognize limitations of selected engineering tools	6
6	Individual & Teamwork	6
6.1	Describe principles of team dynamics and leadership	6

#	Outcome	Learning Outcome(s)
6.2	Understand all members' roles and responsibilities within a team	6
6.3	Execute and adapt individual role to promote team success through, for example, timeliness, respect, positive attitude	6
6.4	Apply strategies to mitigate and/or resolve conflicts	6
6.5	Demonstrate leadership through, for example, influencing team vision and process, promoting a positive team culture, and inspiring team members to excel	6
7	Communication Skills	5
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	5
7.3	Construct the finished elements using accepted norms in English, graphical standards, and engineering conventions, as appropriate for the message and audience	5
7.4	Substantiate claims by building evidence-based arguments and integrating effective figures, tables, equations, and/or references	5

5 Teaching and Learning Activities

5.1 Lecture

Topic(s): Introduction
Reference(s): Chapter 1

Topic(s): Instruction Set Architecture
Reference(s): Appendix A

Topic(s): Pipelining Basics (Review)
Reference(s): Appendix C

Topic(s): Memory Hierarchy (Review)
Reference(s): Appendx B

Topic(s): Advanced Caches
Reference(s): Chapter 2

Topic(s): Superscalar
Reference(s): Chapter 3

Topic(s): Out Of Order (OOO) Execution

Reference(s): Chapter 3

Topic(s): Very Large Instruction Word (VLIW)
Reference(s): Chapter 3

Topic(s): Multithreading
Reference(s): Chapter 3

Topic(s): Vector Processors
Reference(s): Chapter 4

Topic(s): Warehouse-Scale Computers
Reference(s): Chapter 6

Topic(s): Extra Topics

Please note that lecture topics and orders are subject to changes.

All updated information will be posted reguraly on the course webpage.

5.2 Lab

Topic(s): Lab 0: Using SimpleScalar

Topic(s): Lab 1: Profiling Applications and Comparing ISAs

Topic(s): Lab 2: Cache Memories

Topic(s): Lab 3: Instruction Pipelining

Topic(s): Lab 4: Superscalar Processors

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6 Assessments

6.1 Marking Schemes & Distributions

Name	Scheme A (%)
Labs	30
Presentation	5
Midterm	25
Final Exam	40
Total	100

6.2 Assessment Details

Labs (30%)
Learning Outcome(s): 1,2,3,4,6
All lab information will be posted in the course webpage

Group Presentation (5%)
Learning Outcome(s): 5
1 topic per group. A list of suggested papers will be given in lectures. Presentations will be held during lecture times in the last two/three weeks of the semester. A detailed table with group numbers will be given during lectures once groups are constructed.

Midterm (25%)
Date: week eight, TBD
Learning Outcome(s): 1,2,3,4,5
Midterm will be held during the lecture time slot in the eight's week of the course.

Final Exam (40%)
Date: Friday, April 12th 2019, 11:30AM - 01:30PM, Room TBD.
Learning Outcome(s): 1,2,3,4,5

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7 Course Statements

7.1 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. See the undergraduate calendar for information on regulations and procedures for Academic Consideration:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor at the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Missed Midterm Exam: If you miss the midterm due to grounds for granting academic consideration or religious accommodation, the weight of the missed midterm will be added to the final exam. **There will be no makeup midterm tests.**

Lab Work: You must attend and complete all laboratories. If you miss a lab with grounds for granting academic consideration or religious accommodation, arrangements must be made with the instructor to complete a makeup lab upon presentation of a written request and suitable documentation.

Late Lab Reports: Late submissions of lab reports will not be accepted.

7.2 Relationships with other Courses & Labs

Previous Course:

ENGG*3380: Internal bus structure, registers, control sequence design, microprogramming and memory organization.

ENGG*3380 discussed fundamentals of computer architecture. This course build on this information by providing advanced topics in computer architecture.

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8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor’s role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are

working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

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9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.3 Drop Date

Courses that are one semester long must be dropped by the end of the fortieth class day; two-semester courses must be dropped by the last day of the add period in the second semester. The regulations and procedures for course registration are available in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to book their exams at least 7 days in advance and not later than the 40th Class Day.

More information can be found on the SAS website
https://www.uoguelph.ca/sas

9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff, and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph’s procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars
