

COURSE SYLLABUS

CMPT 215: INTRODUCTION TO COMPUTER ORGANIZATION AND ARCHITECTURE

Catalogue Description

An introduction to the design of contemporary computer systems, focusing on the hardware-software interface and the upper hardware levels. Topics include machine and assembly language, computer arithmetic, the processor datapath and control, pipelining, memory hierarchies, and I/O systems.

Prerequisites: CMPT 214 and one of MATH 104, MATH 110, MATH 121, MATH 123, MATH 125, MATH 133, MATH 163, MATH 176, STAT 242 or STAT 245 (or equivalent)

Note: A student cannot receive credit for more than one of CMPT 215, EE 331, or CME 331.

Class Time & Location: M W F, 12:30-13:20, Thorv 124 (Section 02)
T Th, 8:30-9:50, Thorv 124 (Section 04)
T Th, 2:30-3:50, Thorv 124 (Section 06)

Tutorials: M, 16:30-17:50, Thorv S320 (T02)
T, 10:00-11:20, Thorv S311 (T04)
T, 13:00-14:20, Thorv S320 (T06)
W, 16:30-17:50, Thorv S320 (T08)
Th, 10:00-11:20, Thorv S311 (T10)
Th, 10:00-11:20, Thorv S320 (T12)
Th, 11:30-12:50, Thorv S320 (T14)
F, 14:30-15:50, Thorv S320 (T16)
You are free to participate in any tutorial session(s) you wish, regardless of which tutorial section you are registered in. Tutorials will begin the week of **January 13th**.

Website: Canvas

Instructor Information

Section 02 Instructor: Derek Eager

Contact: Email: eager@cs.usask.ca

Office: Thorv 281.2

I am usually able to respond to emails received during the day (8:30 am to 4:30 pm) on weekdays (Monday to Friday) within a few hours, depending on other commitments. Emails received during the evening may not be responded to until the following weekday morning; emails received on a weekend may not be responded to until the following Monday.

Section 04 Instructor: Kemin Wang

Contact: Email: kemin.wang@usask.ca

Office: Thorv 281.7

By appointment.

Section 06 Instructor: Jordan Schidlowsky

Contact: Email: jls577@mail.usask.ca

Office: Thorv 281.5

By appointment.

Course Overview and Objectives

Most students will enter this class with familiarity with computer systems as end-users and as high-level language programmers. This class is designed to provide an introduction to a portion of what lies below the application programming interface, namely, the basic organization and architecture of contemporary computer systems.

By the time you complete this course, you should be able to:

- Describe the basic hardware organization of a computer system and the hardware/software interface
- Use the factors of clock rate, instruction count, and CPI to evaluate performance
- Describe how data and instructions are represented in a computer system, and convert among different representations
- Develop and debug RISC-V assembly language programs
- Describe the main characteristics and design principles of RISC-V machine language
- Explain how assembly language programs are assembled and linked
- Design simple digital logic circuits
- Describe how the basic arithmetic operations can be implemented in an ALU
- Describe, and analyze the operation of, simple processor datapath and control designs
- Describe, and analyze the operation of, processor pipelining, including techniques for dealing with pipeline hazards
- Describe, and analyze the operation of, processor caching and virtual memory management techniques
- Explain how I/O is performed, and describe the basic characteristics of SSD and magnetic disk storage systems
- Compare and contrast the main approaches to parallel computing

Student Evaluation

There will be 5 equally weighted assignments. **Tentative** due dates for the assignments are Friday January 24th, Friday February 7th, Friday February 28th, Friday March 14th, and Friday March 28th. These assignments will involve both programming and non-programming exercises, with programming to be done in RISC-V assembly language. Due dates for the assignments are strict – if you require an extension for some special reason (e.g. medical), you must contact the instructor as soon as feasible. **An 80 minute in-person midterm exam will be held Wednesday March 5th, 7:00pm – 8:20pm, in ARTS 143.** A three-hour in-person final exam will be held during a time slot that will be assigned in the University final exam schedule. The midterm exam and the final exam will be closed book, with no electronic devices permitted, and will include a mix of short answer, problem-solving, and coding questions.

Grading Scheme

Assignments (5)	30 %
Midterm Exam	20 %
Final Exam	50 %
Total	100%

Final Exam Scheduling:

The Registrar schedules all final examinations, including deferred and supplemental examinations. Students are advised not to make travel arrangements for the exam period (April 7th through April 30th inclusive) until the official exam schedule has been posted.

Note: All students must be properly registered in order to participate in and receive credit for this course.

Textbook Information

Required Text

Computer Organization and Design RISC-V Edition, 2nd edition, David A. Patterson and John L. Hennessy, Morgan Kaufmann/Elsevier, 2021. ([U. of S. bookstore link](#))

Programming Environment

The programming work for this course requires use of the QEMU simulator, provided on the Linux machines in Spinks and on tuxworld.cs.usask.ca. You may install QEMU on your home systems.

Lecture Schedule (all timings approximate)

1. Computer Systems and Performance (1 week)
Overview of computer systems organization, factors determining performance, performance metrics, benchmarking, energy consumption.
Readings: Chapter 1.
2. Machine and Assembly Language (3.5 weeks)
RISC-V machine and assembly language, integer representations, addressing methods, instruction sets, procedures, implementing assembly language – assembly and linking.
Readings: Chapter 2.
3. Computer Arithmetic and Logic Design (2 weeks)
Basics of digital logic circuits, implementing arithmetic operations, floating point number representation and operations.
Readings: Chapter 3 and portions of Appendix A.
4. Processor Implementation (2.5 weeks)
Datapath and control, a single clock cycle implementation of a MIPS subset, pipelining, multiple issue.
Readings: Chapter 4 and portions of Appendix A.
5. Memory (2 weeks)
Memory hierarchies, temporal and spatial locality, caches, virtual memory, virtual machines, coherence and consistency.
Readings: Chapter 5.
6. Selected Topics from I/O and Parallel Computing (1 week)
Performing I/O, solid-state drives (SSDs) and magnetic disks, RAID, parallel computing approaches.
Readings: Chapter 6 and Sections 2.11, 3.6, 3.7, 5.2, 5.11.

University of Saskatchewan Grading System (for undergraduate courses)

Exceptional (90-100) A superior performance with consistent evidence of

- a comprehensive, incisive grasp of the subject matter;
- an ability to make insightful critical evaluation of the material given;
- an exceptional capacity for original, creative and/or logical thinking;
- an excellent ability to organize, to analyze, to synthesize, to integrate ideas, and to express thoughts fluently.

Excellent (80-90) An excellent performance with strong evidence of

- a comprehensive grasp of the subject matter;
- an ability to make sound critical evaluation of the material given;
- a very good capacity for original, creative and/or logical thinking;
- an excellent ability to organize, to analyze, to synthesize, to integrate ideas, and to express thoughts fluently.

Good (70-79) A good performance with evidence of

- a substantial knowledge of the subject matter;
- a good understanding of the relevant issues and a good familiarity with the relevant literature and techniques;
- some capacity for original, creative and/or logical thinking;
- a good ability to organize, to analyze and to examine the subject material in a critical and constructive manner.

Satisfactory (60-69) A generally satisfactory and intellectually adequate performance with evidence of

- an acceptable basic grasp of the subject material;
- a fair understanding of the relevant issues;
- a general familiarity with the relevant literature and techniques;
- an ability to develop solutions to moderately difficult problems related to the subject material;
- a moderate ability to examine the material in a critical and analytical manner.

Minimal Pass (50-59) A barely acceptable performance with evidence of

- a familiarity with the subject material;
- some evidence that analytical skills have been developed;
- some understanding of relevant issues;
- some familiarity with the relevant literature and techniques;
- attempts to solve moderately difficult problems related to the subject material and to examine the material in a critical and analytical manner which are only partially successful.

Failure <50 An unacceptable performance

Course Policies

Academic courses policy applies (<https://policies.usask.ca/policies/academic-affairs/academic-courses.php>).

Use of Generative AI Tools

Any use of Generative AI tools (e.g., ChatGPT) for the course assignments is prohibited and constitutes academic misconduct.

Recording of Lectures

Students may record lectures if desired. More information on class recordings can be found in the Academic Courses Policy (<https://policies.usask.ca/policies/academic-affairs/academic-courses.php#|ClassDelivery>).

Late Assignments

Due dates for assignments are strict – if an extension is required for some special reason (e.g. medical) the instructor must be contacted as soon as possible.

Missed Assignments

Students who do not submit anything for an assignment by the due date (possibly as extended by the instructor) will receive a grade of zero for it.

Missed Examinations

1. Midterm exam: Students who miss the midterm exam should contact the instructor as soon as possible. If it is known in advance that the midterm will be missed, the instructor should be contacted before the exam.
2. Final exam: “A student who is absent from a final examination for medical reasons (such as illness) or compassionate reasons (such as the illness of a child or death of a loved-one) is responsible for contacting the Undergraduate Student Office to request a [deferred examination](#). The application must be initiated within **three business days** of the missed examination and must be accompanied by documentation (letter from a doctor, etc.). The form and supporting documentation must be returned within 5 days of the initial request.” (<https://programs.usask.ca/arts-and-science/policies.php>)

Incomplete Course Work and Final Grades

“When a student has not completed the required course work, which includes any assignment or examination including the final examination, by the time of submission of the final grades, they may be granted an extension to permit completion of an assignment, or granted a deferred examination in the case of absence from a final examination.

Extensions past the final examination date for the completion of assignments must be approved by the Department Head, or Dean in non-departmentalized Colleges, and may exceed thirty days only in unusual circumstances. The student must apply to the instructor for such an extension and furnish satisfactory reasons for the deficiency. Deferred final examinations are granted as per College policy.

In the interim, the instructor will submit a computed percentile grade for the class which factors in the incomplete coursework as a zero, along with a grade comment of INF (Incomplete Failure) if a failing grade.

In the case where the student has a passing percentile grade but the instructor has indicated in the course outline that failure to complete the required coursework will result in failure in the course, a final grade of 49% will be submitted along with a grade comment of INF (Incomplete Failure).

If an extension is granted and the required assignment is submitted within the allotted time, or if a deferred examination is granted and written in the case of absence from the final examination, the instructor will submit a revised assigned final percentage grade. The grade change will replace the previous grade and any grade comment of INF (Incomplete Failure) will be removed.

A student can pass a course on the basis of work completed in the course provided that any incomplete course work has not been deemed mandatory by the instructor in the course outline and/or by College regulations for achieving a passing grade.” (<https://policies.usask.ca/policies/academic-affairs/academic-courses.php>)

For policies governing examinations and grading, students are referred to the Assessment of Students section of the University policy “Academic courses: class delivery, examinations, and assessment of student learning” (<https://policies.usask.ca/policies/academic-affairs/academic-courses.php>)

Copyright

Course materials are provided to you based on your registration in a class, and anything created by your professors and instructors is their intellectual property, unless materials are designated as open

education resources. This includes exams, PowerPoint/PDF slides and other course notes. Additionally, other copyright-protected materials created by textbook publishers and authors may be provided to you based on license terms and educational exceptions in the Canadian Copyright Act (see <http://laws-lois.justice.gc.ca/eng/acts/C-42/index.html>).

Before you copy or distribute others' copyright-protected materials, please ensure that your use of the materials is covered under the University's Fair Dealing Copyright Guidelines available at <https://library.usask.ca/copyright/general-information/fair-dealing-guidelines.php>. For example, posting others' copyright-protected materials on the open web is not covered under the University's Fair Dealing Copyright Guidelines, and doing so requires permission from the copyright holder.

For more information about copyright, please visit <https://library.usask.ca/copyright/index.php> where there is information for students available at <https://library.usask.ca/copyright/students/rights.php>, or contact the University's Copyright Coordinator at copyright.help@usask.ca or 306-966-8817.

Integrity

The University of Saskatchewan is committed to the highest standards of academic integrity (<https://academic-integrity.usask.ca/>). Academic misconduct is a serious matter and can result in grade penalties, suspension, and expulsion. Students are expected to act with academic integrity. Students are encouraged to complete the Academic Integrity Tutorial to understand the fundamental values of academic integrity and how to be a responsible scholar and member of the USask community (tutorial link: <https://libguides.usask.ca/AcademicIntegrityTutorial>). Students can access campus resources that support development of study skills, time and stress management, and ethical writing practices important for maintaining academic integrity and avoiding academic misconduct.

Students are expected to be familiar with the academic misconduct regulations (<https://governance.usask.ca/student-conduct-appeals/academic-misconduct.php#About>).

- Definitions appear in Section II of the academic misconduct regulations.
- The academic misconduct regulations apply regardless of type of assessment or presence of supervision during assessment completion.
- Students are advised to ask for clarification as to the specific expectations and rules for assessments in all of their courses.
- Students are urged to avoid any behaviour that could result in suspicions of cheating, plagiarism, misrepresentation of facts. Students should note that posting copyrighted course materials (e.g., notes, questions, assignments or exams) to third party websites or services or other forum or media without permission is an academic or non-academic misconduct offense.

Non-academic offenses are dealt with under the [Standard of Student Conduct in Non-Academic Matters and Procedures for Resolution of Complaints and Appeals](#).

Access and Equity Services (AES) for Students

Students who have disabilities (learning, medical, physical, or mental health) are strongly encouraged to register with Access and Equity Services (AES) if they have not already done so. Students who suspect they may have disabilities should contact AES for advice and referrals at any time. Those students who are registered with AES with mental health disabilities and who anticipate that they may have responses to certain course materials or topics, should discuss course content with their instructors prior to course add / drop dates. In order to access AES programs and supports, students must follow AES policy and procedures. For more information or advice, visit <https://students.usask.ca/health/centres/access-equity-services.php>, or contact AES at 306-966-7273 or aes@usask.ca.

Students registered with AES may request alternative arrangements for mid-term and final examinations. Students must arrange such accommodations through AES by the stated deadlines. Instructors shall provide the examinations for students who are being accommodated by the deadlines established by AES.

Student Supports

See <https://library.usask.ca/studentlearning/> and <https://students.usask.ca>.

Financial Support

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact Student Central (<https://students.usask.ca/student-central.php>).

College Supports

Students in Arts & Science are encouraged to contact the [Undergraduate Student Office](#) and/or the [Trish Monture Centre for Student Success](#) with any questions on how to choose a major; understand program requirements; choose courses; develop strategies to improve grades; understand university policies and procedures; overcome personal barriers; initiate pre-career inquiries; and identify career planning resources.

Gordon Oakes Red Bear Student Centre

The [Gordon Oakes Red Bear Student Centre](#) is dedicated to supporting the personal, social, cultural, and academic success of Métis, First Nations, and Inuit students.

International Student and Study Abroad Centre

The International Student and Study Abroad Centre (ISSAC) supports student success in their international education experiences at the U of S and abroad. ISSAC is here to assist all international undergraduate, graduate, exchange and English as a Second Language students and their families in their transition to the U of S and Saskatoon. ISSAC offers advising and support on all matters that affect international students and their families and on all matters related to studying abroad. Please visit <https://students.usask.ca/international/issac.php> for more information.

Land Acknowledgement

I would like to acknowledge that the Saskatoon campus of the University of Saskatchewan is on **Treaty Six Territory** and the **Homeland of the Métis**. We pay our respect to the First Nation and Métis ancestors of this place and reaffirm our relationship with one another. I would also like to recognize that some may be attending this course from other traditional Indigenous lands. I ask that you take a moment to make your own Land Acknowledgement to the peoples of those lands. In doing so, we are actively participating in reconciliation as we navigate our time in this course, learning and supporting each other.