

Fall 2021, CS 245, Logic and Computation

Course Meet Times

Lectures:

LEC 001: Online
LEC 002: Online
LEC 003: Online
LEC 004: Online
LEC 005: Online
LEC 006: Online
LEC 007: Online
LEC 008: Online

Optional live sessions with instructors will be organized throughout the term. Details on these sessions will be made available on the course LEARN Web site. Other useful information will be posted on the unsecured course website:

<https://student.cs.uwaterloo.ca/~cs245/>

Tutorials:

TUT 101: 9:00 – 9:50 a.m., Fridays
TUT 102: 10:00 – 10:50 a.m., Fridays
TUT 103: 11:00 – 11:50 a.m., Fridays
TUT 104: 1:00 – 1:50 p.m., Fridays
TUT 105: 2:00 – 2:50 p.m., Fridays
TUT 106: 3:00 – 3:50 p.m., Fridays

Students are asked to connect to the tutorial session in which they have been registered. Details on how to connect to these sessions will be communicated to students during the first week of classes.

Instructor Contact Information

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For instructor and instructional apprentice office hours, see the course Web site:

<https://student.cs.uwaterloo.ca/~cs245/>

Course Description

CS 245 plays a key role in the development of mathematical skills required in the Computer Science program, and thus complements MATH 135 (Algebra), MATH 239 (Graph Theory and Enumeration), and STAT 230 (Probability). The course covers a variety of topics related to logic and computation that are required as background for other courses in Computer Science. It differs both in tone and content from a logic course one would typically find in a mathematics program. The course aims to

- Develop mathematical reasoning skills
- Improve understanding of propositional and first-order logic, including key notions, such as: expressing natural language statements as logical formulas, distinguishing between correct and incorrect reasoning (between valid and invalid logical arguments), constructing a formal proof, distinguishing between syntax and semantics
- Explore the limits of computers, including decidability and undecidability

Course Objectives

At the end of the course, students should be able to

- Formalize English sentences into properly formed formulas in propositional and first-order logic and, conversely, interpret such formulas in English
- Formalize the notion of correct reasoning and proof, and be able to construct formal proofs
- Realize the limitations of formal proof systems
- Understand the applications of logic to computer science

Textbook

Lu Zhongwan, Mathematical Logic for Computer Science, 2nd Ed., World Scientific

Topic Overview

Introduction

- History, motivation, connections to computer science

Propositional Logic

- Connectives, truth tables, translation between English and propositional logic
- Syntax: formulas in propositional logic. Structural induction and its use in proving statements about formulas
- Semantics: truth valuations, how to (semantically) prove that arguments in propositional logic are valid (i.e. correct, sound)
- Essential laws for propositional logic, formula simplification, Conjunctive/Disjunctive Normal Form(s)
- Adequate sets of connectives
- Formal deduction for propositional logic; Proving arguments valid by formal deduction (syntactically)
- Soundness and completeness of formal deduction
- Applications of propositional logic to computer science, such as: Automated proofs: Resolution, Davis-Putnam Procedure; Hardware and software verification

First-Order Logic

- Limitations of propositional logic, and the necessity of first-order logic for reasoning about objects and properties
- Quantifiers, universe of discourse, translation between English and first-order logic formulas
- Syntax of first-order logic, terms, formulas
- Semantics of first-order logic, valuations
- Proving argument validity in first-order logic (semantically)
- Formal deduction in first-order logic; Proving argument validity by formal deduction (syntactically)
- Applications of first-order logic to computer science, such as: Automated theorem provers and verifiers; Databases

Decidability and Peano Arithmetic

- Turing Machine as a model of computation
- Undecidability: Basic notions, undecidability of the Halting Problem and other problems
- The Peano axioms for number theory (including the induction axiom), undecidability of Peano Arithmetic
- Gödel's Incompleteness Theorem

Review for midterm and final assessments (optional)

Grading Scheme

- Practice Quizzes: 5%
- Marked Quizzes: 10%
- Crowdmark Assignments: 35%
- Mid-Term Assessment: 20%
- Final Assessment: 30%

Notes:

1. You must pass the weighted Assessment portion of the course (the Mid-Term Assessment and the Final Assessment) in order to pass the course.
2. Here are the details about how the **practice quizzes** will work:
 - a. There will be at least one practice quiz per week.
 - b. The purpose of the practice quizzes is to give you more frequent practice with the course material than the Crowdmark assignments will.
 - c. Each practice quiz will be automatically graded once you submit it, so that you will have immediate feedback about how you did.
 - d. You may take each practice quiz as many times as you like.
 - e. We will track the number of practice quizzes that you submit (at least once) during the term.
 - f. Your score out of 5 will be computed as the proportion of 75% of the available practice quizzes you submit (at least once), to a maximum of 5. This means that if you submit at least 75% of the available practice quizzes (at least once), then your score will be 5. For example,

- i. If there are 12 practice quizzes in total, and you submit 7 of them (at least once), then your grade will be $5(7/9) \approx 3.9$.
 - ii. If there are 20 practice quizzes in total, and you submit 17 of them (at least once), then your grade will be 5.
 - g. Your scores on the practice quizzes will not matter; only the number of practice quizzes you submit (at least once) will matter.**
 - h. Your grade on the practice quizzes to date will be updated on the LEARN Gradebook at the end of each week.
 - i. All practice quizzes will be due at 11:59 PM, Waterloo time, on the last day of lectures. After that deadline, the quizzes will remain open for practice purposes, but submitting additional quizzes will not increase your grade.
3. Here are the details about how the **marked quizzes** will work:
- a. There will be a marked quiz due in each week when there will not be a Crowdmark assignment or a mid-term assessment due. The due dates for the marked quizzes are displayed on the course schedule page.
 - b. No late submissions of marked quizzes will be accepted.
 - c. From the time you start taking the marked quiz, you will have one hour in which to complete it. You must submit your quiz before this hour elapses **and** before the due date and time to receive credit.
 - d. You will have only one attempt at each marked quiz.
 - e. Your grading for each marked quiz will be displayed on LEARN after the due date and time has passed.
 - f. Your marked quiz will be randomly customized for you. We will ensure that the variations of any given question are all of the same difficulty.

Policies

Crowdmark Assignments:

For full credit, you must submit your solutions by the specified due date and time. A late penalty will automatically be applied for each hour that you are late in submitting. The percentage for that hourly late penalty will be announced before the first Crowdmark assignment is released.

Links to assignments will appear in the content section of our course on LEARN. The given dates, times and topics are subject to change. Each assignment has a due time, in Waterloo local time. You must submit your assignment to Crowdmark by the specified due time. It is your responsibility to start uploading your solutions early enough to have time to resolve any minor technical issues with Crowdmark before the due time. You should receive an email from Crowdmark with instructions and address. If the Crowdmark site fails on the due date, please email your assignment to the course coordinator at ddvorski@uwaterloo.ca before the due time. Crowdmark has a separate location for each page of questions. You may submit any number of pages, in either PDF or JPEG format, for each question page. If you have a single file with all of your answers, then you will need to split it up for submission. Most students hand-write and scan their solutions for upload. We recommend this as the simplest and fastest way to create and submit solutions. (You may also take a JPEG photograph; check that it is easily readable before submitting.) Once all assignments are graded, you will receive via email a link to retrieve your graded paper. The grade will also appear in the Gradebook in LEARN.

Academic Integrity:

The work you submit must be your own. Acknowledge any sources you have used. You may discuss the assignment questions verbally with others, but you should come away from these discussions with no written or electronic records. Write your solutions in your own words, from your own head.

Assignment Grade Appeals:

If you wish to request a regrading of your submission, fill out the regrading request form on the course website, and submit it to the appropriate LEARN dropbox, within one week following the release of grades for that assignment.

Mental Health Resources

Mental Health: If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support.

On-campus Resources

- Campus Wellness <https://uwaterloo.ca/campus-wellness/>
- Counselling Services: counselling.services@uwaterloo.ca / 519-888-4567 ext 32655 / Needles Hall North 2nd floor, (NH 2401)
- MATES: one-to-one peer support program offered by Federation of Students (FEDS) and Counselling Services: mates@uwaterloo.ca
- Health Services service: located across the creek from Student Life Centre, 519-888-4096.

Off-campus Resources

- Good2Talk (24/7): Free confidential help line for post-secondary students. Phone: 1-866-925-5454
- Here 24/7: Mental Health and Crisis Service Team. Phone: 1-844-437-3247
- OK2BME: set of support services for lesbian, gay, bisexual, transgender or questioning teens in Waterloo. Phone: 519-884-0000 extension 213

Diversity: It is our intent that students from all diverse backgrounds and perspectives be well served by this course, and that students' learning needs be addressed both in and out of class. We recognize the immense value of the diversity in identities, perspectives, and contributions that students bring, and the benefit it has on our educational environment. Your suggestions are encouraged and appreciated. Please let us know ways to improve the effectiveness of the course for you personally or for other students or student groups.

In particular:

- We will gladly honour your request to address you by an alternate/preferred name or gender pronoun. Please advise us of this preference early in the semester so we may make appropriate changes to our records.
- We will honour your religious holidays and celebrations. Please inform of us these at the start of the course.
- We will follow AccessAbility Services guidelines and protocols on how to best support students with different learning needs.

University-Mandated Statement on Policies

Academic integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check [the Office of Academic Integrity](#) for more information.]

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read [Policy 70, Student Petitions and Grievances, Section 4](#).

When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for his/her actions. [Check [the Office of Academic Integrity](#) for more information.] A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate associate dean. For information on categories of offences and types of penalties, students should refer to [Policy 71, Student Discipline](#). For typical penalties, check [Guidelines for the Assessment of Penalties](#).

Appeals: A decision made or penalty imposed under [Policy 70, Student Petitions and Grievances](#) (other than a petition) or [Policy 71, Student Discipline](#) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to [Policy 72, Student Appeals](#).

Note for students with disabilities: [AccessAbility Services](#), located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

Intellectual Property. Students should be aware that this course contains the intellectual property of their instructor, TA, and/or the University of Waterloo. Intellectual property includes items such as:

- Lecture content, spoken and written (and any audio/video recording thereof);
- Lecture handouts, presentations, and other materials prepared for the course (e.g., PowerPoint slides);
- Questions or solution sets from various types of assessments (e.g., assignments, quizzes, tests, final exams); and
- Work protected by copyright (e.g., any work authored by the instructor or TA or used by the instructor or TA with permission of the copyright owner).

Course materials and the intellectual property contained therein, are used to enhance a student's educational experience. However, sharing this intellectual property without the intellectual property owner's permission is a violation of intellectual property rights. For this reason, it is necessary to ask the instructor, TA and/or the University of Waterloo for permission before uploading and sharing the intellectual property of others online (e.g., to an online repository).

Permission from an instructor, TA or the University is also necessary before sharing the intellectual property of others from completed courses with students taking the same/similar courses in subsequent terms/years. In many cases, instructors might be happy to allow distribution of certain materials. However, doing so without expressed permission is considered a violation of intellectual property rights.

Please alert the instructor if you become aware of intellectual property belonging to others (past or present) circulating, either through the student body or online. The intellectual property rights owner deserves to know (and may have already given their consent).