Computer Architecture I
CEG 2136 A00
2024 Fall Term

Course Information

Class Schedule: MON 10:00:00 11:20:00 WED 08:30:00 09:50:00

All components of this course are delivered in person, including lectures (in DMS 1160), tutorials and laboratories:

Tutorials:
- A04: Th 5:30PM - 6:50PM, (CRX) C010
- A05: Tu 11:30AM - 12:50PM, (DMS) 1130

Laboratories:
- A01: Tu 4:00PM - 6:50PM, (CBY) 302
- A02: We 7:00PM - 9:50PM, CBY) B302
- A03: Th 11:30AM - 2:20PM, (CBY) B302

Instructor Information

Name: Basim Hafidh

Email: BHAFIDH@UOTTAWA.CA

Office Hours: Posted on BrightSpace (BS)

Other instructor(s):

Name	Email	Office Hours	Responsibilities

Before emailing a question, please fully read this syllabus and explore the associated sources. The answers to many questions can be found in this document and students may be

referred back to the syllabus if the answer is already available. Please allow **at least 2 business days** for replies before pursuing another route of communication.

Official Course Description

Design a digital computer to execute a given instruction set. Design of digital computers. Register transfer and microoperations. Designing the instruction set, CPU and CPU control. Basic machine language programming. Using pipelines for CPU design. Designing the memory unit. Designing Imput-Output subsystem.

Additional Course Description

"Computer Architecture I" is addressed to a broad range of audience, for all undergraduate programs offered in the *School of Electrical Engineering and Computer Science*, from Electrical Engineering to Computer Science and Computing Technologies. In this course, Hardware meets Software at the closest level. Students learn fundamentals of computer organization, while designing, implementing and testing an educational computer. A traditional "bottom-up" design approach is employed to build a basic computer, by devising and analyzing logic components and dedicated digital modules that eventually are used for assembling a processor capable to execute a specified instruction list. The basic processor is practically implemented on a FPGA board, and, in order to demonstrate its operation, short programs (in machine code and assembly language) are conceived and run on this platform.

Course Learning Outcomes

General Course Learning Outcomes

The main objective of this course is to introduce students to the foundations of computer organization and architecture. They will understand the computer elements and the fundamentals of computer organization and will get knowledge on the principles of computer architecture.

Students will gain experience with basic design at various levels, from instruction set architecture (ISA) to datapath and control logic; small projects will be developed by using modern CAD environments and will be practically implemented on CPLDs or FPGAs.

Developing programs in machine language that run on their own designed/built computers, students will sense and understand the interface between the software and computer hardware.

Specific Course Learning Outcomes

Upon completion of the course, student will be able to:

- Explain internal organization of computers, the relations between its main components and operation principles.
- Apply Boolean algebra techniques to analyze and synthesize computer logic components and to design simple processors.
- Design, implement, simulate and verify computer circuits on modern hardware/software development environments.
- Write assembly language and machine code programs for the computers that they devise
- Communicate accurately and effectively through lab reports

Program Learning Outcomes

Devised at the intersection of electrical engineering and computer science, the Computer Engineering program creates specialists with a comprehensive, but detailed vision, and who are capable of conceiving and developing computer systems that solve problems that require both computer hardware and software expertise.

The ultimate educational objective of this program is to graduate competent computer engineers who satisfy the academic requirements for registration as professional engineers, who are able to communicate effectively, and who are aware of the responsibilities of professional engineers in today's society. More specifically, the educational aims of this program are to provide students with:

- an adequate theoretical and practical education in the broad areas of mathematics, chemistry and physics, but **focusing on computer engineering design, computer science and engineering science**.
- an adequate instruction and training in the design and application of computers, as well as microprocessors' embedding in solving engineering problems.
- an adequate understanding of the economic, environmental, social, and cultural impacts of technology on society, and of the responsibilities that professional engineers have in this regard.
- an adequate appreciation of the methodologies and thought processes of the humanities, the social sciences, and the arts.
- an appreciation of the importance of being able to communicate effectively, and to enhance their written and oral skills accordingly.

Our Computer Engineering program is accredited by the Canadian Engineering Accreditation Board (CEAB), a committee of Engineers Canada.

Teaching Methods

Theory of computer organization and logic structure of its basic components, along with their operation, will be explained in lectures based on multimedia presentations. Solutions to problems inspired from the concepts and methods introduced in the lectures, and which are quite well aligned with the examinations and quizzes questions, will be presented and discussed in tutorials.

All the lecture presentations, along with the documentation and instructions of the laboratory manual, and practicing problems and solutions to the quizzes and examinations will be posted online in the "BrightSpace" Virtual Campus. The same virtual tool will be used for lab reports submission and for individually communicating the results to the students.

A tentative schedule of topics for lectures is presented in the "BrightSpace" Virtual Campus . The schedule is subject to changes.

Experiential Learning Activities

Small projects including design, implementation, computer-based simulation and experimental verification of a basic computer along with its logic components will be carried out by two-student teams in the frame of laboratory sessions; the basic computer's elements will be conceived and developed at home and/or at school on modern software development environments, while contemporary hardware platforms will be used for the practical verification and debugging of the circuits. The experiments will be run in laboratories.

Required Materials

M. Morris Mano, "Computer System Architecture", 3rd edition, Prentice Hall, 1993

Course notes and supporting material will be supplied via the course webpage on Virtual Campus (BrightSpace) for student personal use. All posted materials on this course webpage are intended for student registered in this course personal use only and may not be reproduced or redistributed without prior written consent of the author(s).

Optional Materials

Donald D. Givone, Digital Principles and Design, McGraw Hill,2003

Assessment Strategy

Lab work:	24 %
Quizzes and participation:	6 %
Midterm Exam:	20 % (Monday Oct. 21, 2024)
Final Exam:	50 %

- The passing grade for this course is 50% (D).

- All components of the course (i.e., laboratory reports, assignments, etc.) must be fulfilled; otherwise, students may receive an EIN as a final mark (equivalent to an F). This is also valid for a student who is taking the course for the second time.

Assessment Details

Lab Work: TAs will conduct oral assessment of students' pre-lab preparation and in-lab activity, representing 12% of the course mark. Laboratory rules and regulations will be posted on the course BrightSpace site. Four labs have been organized and will be distributed along the term proportional with their degree of difficulty. You will be working in groups of 2 students. The same group will work together throughout the semester. The FPGA Altera DE2-115 Development & Education Board will be employed to perform the following lab experiments:

1. Introduction to Quartus – FPGA Design Software

2. Design, Simulation and FPGA Implementation of Sequential Logic Circuits

3. Arithmetic Logic Unit

4. Basic computer organization

A lab report is expected from each group after completion of every of the four labs. The lab report should be prepared according to the guidelines found in the lab manual posted on BrightSpace. The report will be submitted electronically (in WORD format) no later than two days before the following lab; this would allow a minimum of two days for the preparation of the next lab. The report of the last lab (#4) will be submitted one week after its completion. The lab reports grades count for 12% of the final course grade. The same grade will be given to all report's authors, but, of course, they may receive individual lab activity assessments.

Quizzes and participation: Unannounced very short quizzes will be run at the end of some lectures on random dates.

The **midterm exam** is a closed book exam and covers material presented in the weeks prior to the midterm. The midterm schedule is on **Monday Oct. 21, 2024**.

 The final exam is also closed book and will be written during the official examination session period at a date established by the university. The questions will cover all material taught during the term including laboratories and tutorials.

University of Ottawa Grading Scheme

Academic Regulation A-3 - Grading System

Letter Grade	Numerical Value	Percentage Value
A+	10	90 - 100
A	9	85 - 89
A-	8	80 - 84
B+	7	75 - 79
B	6	70 - 74
C+	5	65 - 69
C	4	60 - 64
D+	3	55 - 59
D	2	50 - 54
E	1	40 - 49
F	0	0 - 39
ABS	0	Absent
EIN	0	Failure / Incomplete

Assessment Policies and Expectations

Attendance

Attendance for each in class session is mandatory. You must arrive at the start of class, and baring any emergencies, remain for the entire session.

Attendance requirements will be aligned with and will observe the regulations and guidelines established by the Faculty of Engineering.

- Attendance at lectures, labs and tutorials is mandatory. As per academic regulations, students who do not attend 80% of these class activities will not be allowed to write the

examination.

- Each student must attend one discussion group (DGD) and one laboratory group as assigned.
- Cell phones should be turned to silent.

Time Commitment

In order to succeed in a 3-credit course, alongside the standard 3 hours of in-class instruction, students should expect to spend a minimum of 6 hours per week outside of the classroom engaged in activities related to the course, e.g. homework, reading, studying, etc., and should expect a minimum time commitment of 9 hours per week per course (on average).

Language Expectations

This course is delivered in English, and in class interactions, and feedback will also be managed in English. As part of your evaluation will be on your writing abilities, it is recommended to take the appropriate measures to avoid mistakes such as spelling, syntax, punctuation, inappropriate use of terms, etc. You may be penalized up to 15% for poorly written materials, to the professor's discretion.

Mobile Devices

Unless explicitly requested, please refrain from using mobile devices during our class. As our in class time is quite limited, I would ask that you prioritize using this time to engage with class discussions and other content-related activities. Active participation and engagement with the content and your peers helps ensure full participation marks for your contributions this semester.

Late Assignments

All assignments are to be submitted by their due date and time. All late submissions will be immediately docked 5%, with an additional 5% for each subsequent day late to a maximum of 3 days, including weekends. **After 3 days all outstanding assignments will be given a zero (0%) grade**. Exceptions are made only for illness or other serious situations deemed as such by the instructor. University regulations require all absences from exams and all late submissions due to illness to be supported by a medical certificate. Absence for any other serious reason must be justified in writing, to the academic assistants of the Faculty, within five business days following the date of the exam or

submission of an assignment. The Faculty reserves the right to accept or refuse the reason; reasons such as travel, jobs, or any misreading of the examination timetable are not acceptable.

Missed and Deferred Examinations

Students who are excused for missing an exam will be required to write a deferred exam.

Grade Revision Requests

Note that all requests for revision of grades must follow Academic Regulation A-9: Revision of Grades and Appeal :

1. confirm the deadlines associated with Academic Regulation A-9 to request a grade revision;
2. contact your professor for clarifications and/or reasoning behind the assigned grade;
3. if you remain unsatisfied with the outcome, you may submit your request to the chair of the academic unit offering the course.

Your request MUST include:

a. the course title, the course syllabus, the grade assigned and the name of the professor having assigned it;
b. the grounds for the appeal;
c. the assignment/test corrected by the professor, if applicable, and other relevant documents.

Academic Integrity

Preamble

Academic integrity is a fundamental value at the core of all academic activities. The regulation on academic fraud (Academic regulation A-4) defines the acts that can compromise academic integrity, outlines the various sanctions and consequences of such acts, and the procedures for handling allegations and setting sanctions. Further information on academic integrity is available on the webpage: Academic integrity for students.

Definition

1. Any act by a student that may result in a distorted academic evaluation for that student or another student. Academic fraud includes but is not limited to activities such as:
    a. plagiarising or cheating in any way;
    b. submitting work not partially or fully the student's own, excluding properly cited quotations and references. Such work includes assignments, essays, tests, exams, research reports and theses, regardless of whether the work is in written, oral or any other form;
    c. presenting research data that are forged, falsified or fabricated in any manner;
    d. attributing a statement of fact or reference to a fabricated source;
    e. submitting the same work or a significant part of the same piece of work in more than one course, or a thesis or any other piece of work submitted elsewhere without the prior approval of the appropriate professors or academic units;
    f. falsifying or misrepresenting an academic evaluation, using a forged or altered supporting document or facilitating the use of such a document;
    g. taking any action aimed at falsifying an academic evaluation.

Sanctions

1. Students who commit or attempt to commit academic fraud or who are a party to academic fraud are subject to one or more sanctions, such as:
    a. a written warning;
    b. zero for part of the work in question;
    c. zero for the work in question;
    d. zero for the work in question and the loss of additional marks for the course in question;
    e. zero for the work in question, with a final grade no higher than the passing grade for the course in question;
    f. an F or NS grade for the course in question.

Participation Guidelines

You can expect your facilitators to:

1. Support you in your success using the tools and policies described in this syllabus and the associated netiquette guidelines;
2. Treat you with respect and hear and value your viewpoints;

3. Provide constructive feedback and criticism;

4. Deliver sessions and events as scheduled; understanding that emergencies happen, I'll communicate adjustments through virtual campus and email;

5. Respond to all inquiries, received through appropriate channels, within 2 business days.

Learners are expected to take responsibility for their own success.

1. Manage your time appropriately and read carefully over assignment instructions;

2. Participate positively and actively in the course experience, whether in class or online;

3. Come prepared to class having completed required readings or assignments;

4. Turn in assignments on time and in accordance with our late policies;

5. Proactively seek out support, attend office hours, or reach out to TAs or the Student Support Services as needed;

6. Demonstrate utmost academic integrity and respect.

Netiquette Guidelines

It is important to recognize that online spaces are extensions of our classrooms and certain behaviors are expected when communicating with both your instructors and peers in these spaces. For the most part, online etiquette, or netiquette, is similar to etiquette in a face-to-face classroom; we all want to make sure our digital impressions are clear and positive.

General Guidelines

- **Be safe.** Don't share your password with anyone, it is the only thing protecting you from pranks or more serious harm. Change your password if you think someone else might know it. Always log out when you are finished using the system. Be careful with personal information (both yours and other's).

- **Be prepared.** Come to synchronous sessions ready to learn and participate! Dress as if you were in class and keep distractions and interruptions to a minimum.

- **Be respectful to your instructors and your peers.** Post only what you would say in a face-to-face conversation. Avoid offensive language, off-color jokes, insults, or threats. Be cautious with humor or sarcasm as tone can easily be lost in an email or discussion posts. Always use your professor's proper title, Dr. or Prof., and, unless invited, do not refer to them by first name.

- **Be clear and concise.** Support accessibility in your posts and discussions by using standard fonts such as Arial or Calibri and using a size 10 or 12 pt. font. Avoid slang terms such as

"wassup?", texting abbreviations such as "u" instead of "you", and emoticons. The caps lock feature CAN BE INTERPRETTED AS YELLING.

- **Be kind.** Criticism should be constructive; don't correct insignificant problems in front of the entire class. Avoid posting online when you are angry or tired. Save a draft and review it later when you are calmer. Don't share emails or messages that were sent directly to you without the sender's permission. If you see a post you believe may have been posted accidentally, let the poster know about it privately.

- **Be patient and understanding.** Ask for clarification if meaning or context is unclear. Be forgiving of other people's mistakes, and cheerfully acknowledge your own when you make them. Demonstrate that you are trying to understand a differing viewpoint by acknowledging and restating the other person's view in your own words.

Email Guidelines

- **Be aware.** Please respect that we all have many responsibilities and we may need to time to respond to your inquiries. Your facilitators endeavour to respond to all emails within **2 business days**. You can also bring questions to in-person or online office hours, further communication guidelines are included in the course syllabus.

- **Be professional.** Use official communication channels, such as uOttawa email or appropriate Discussion boards, to approach your course facilitators and peers. Use a descriptive subject line, including your course code. Be brief in describing your concerns and pose clear questions. Sign your message with your name and return e-mail address.

- **Be certain.** Review before you send. Does it make sense? Are there typos that might confuse your meaning? Does it follow the general rules of netiquette? Think before you send the e-mail to multiple people; is it necessary or helpful for them to be involved? If you are sending an email while upset or angry, consider a 24-hour resting or cooling off period before sending.

Discussion Guidelines

- **Be constructive.** Make your point, stay on topic, and don't forget to complete the task as directed. Take your posts seriously and review and edit your posts before sending. Cite your sources, just as you would for a paper or a face-to-face discussion.

- **Be active.** Participate and contribute to the discussions and read all messages in a thread before replying. Don't repeat someone else's post without adding something of your own to it. Avoid short, generic replies such as, "I agree.", include why you agree or add to the previous point.

- **Be open-minded.** Always be respectful of others' opinions even when they differ from your own. Challenge ideas rather than the individual who offered them. Approach discussions with the goal of increasing everyone's knowledge.

Course Calendar

Date	Lecture	Tentative Topic
Week 1	L1	Introduction, Boolean Algebra, Logic function representation / 1.2-1.4
Week 2	L2	Logic Circuits Minimization/1.4, Combinational Circuits/1.5;
	L3	Digital Logic Circuits - Flip - flops / 1.6,
Week 3	L4	Digital Logic Circuits - Sequential Circuits /1.7
	L5	Digital Logic Circuits - Sync Counter Chapter #2 Digital Components - Decoders, Encoders, Multiplexors, parallel Registers/ 2.1-2.4
Week 4	L6	Digital Components - Shift Registers, Multi-function registers /2.5 Binary Counters /2.6;
	L7	Digital Components - Binary Counters /2.6; Multi-function registers /2.5 Chapter #3 Data Representation - Data Types, Integer Representation,
Week 5	L8	Data Representation - Fixed-Point Representation, Arithmetic Operations / 3.1-3.4
	L9	Data Representation - Floating Point Representation / 3.1-3.4 Other Binary Codes, Error Detection Codes / 3.5-3.6 ; Register Transfer & Microoperations - RTL, Register & Bus transfer, Arithmetic Microoperations / 4.1-4.4
Week 6	L10	Register Transfer & Microoperations - Logic Microoperations, Shift Microoperations, Arithmetic Logic Shift Unit / 4.4-4.7
	L11	Digital Components - Memories /2.7 Basic Computer Organization and Design - Instruction Codes/5.1
Week 7	L12	Basic Computer Organization and Design - Addressing Modes /5.1, Computer Registers / 5.2
	L13	Basic Computer Organization and Design - Computer Instructions /5.3 ASM, Timing and Control / 5.4-
Week 8	L14	Basic Computer Organization and Design - Instruction Cycle , Register Reference Instructions / 5.5 LAb4 (without ALL equations),
	L15	Basic Computer Organization and Design - Memory Reference Instructions / 5.6
Week 9	L16	Basic Computer Organization and Design - Input-Output and Interrupt / 5.7
	L17	Basic Computer Organization and Design - Complete Computer Description, Design of Basic Computer, Design of Accumulator Logic / 5.8-5.10
Week	L18	Processor Control Unit Machine Language, Assembly Language / 6.1-6.4

10		
	L19	- Programming the Basic Computer - The Assembler/ 6.4, Program Loops/ 6.5
Week 11	L20	- Programming the Basic Computer - Programming Arithmetic and Logic Operations /6.6, Subroutines /6.7
	L21	Programming the Basic Computer - Input-Output Programming / 6.8
Week 12	L22	Microprogrammed Control /7.1-7.3
	L23	Assembly Language Practice
Week 13	L24	Final Review

Bibliography

[1] Computer System Architecture, 3rd edition, Prentice Hall, 1993

[2] Donald D. Givone, Digital Principles and Design, McGraw Hill, 2003

University Policies

Prevention of Sexual Violence

If you feel unsafe, call 9-1-1 or reach out to campus protective services at 613-562-5411.

The University of Ottawa has a zero-tolerance policy for any sexual act or act targeting a person's sexuality, gender identity or gender expression. This includes both physical and psychological act that are committed, threatened, or attempted against a person without the person's consent, such as sexual assault, sexual harassment, stalking, indecent exposure, voyeurism, sexual exploitation, and cyberbullying. The University, as well as various employee and student groups, offers a variety of services and resources to ensure that all uOttawa community members have access to confidential support and information, and to procedures for reporting an incident or filing a complaint. For more information, please visit https://www.uottawa.ca/about-us/respect/sexual-violence-support-and- prevention

Academic Accommodations

The Human Rights Office and the Student Academic Success Service (SASS) support students t o remove barriers to accessibility. The University has always strived to meet the needs of

individuals with learning disabilities or with other temporary or permanent functional disabilities (hearing/visual impairments, sustained health issues, mental health or learning disabilities), and the campus community works collaboratively so that you can develop and maintain your autonomy, as well as reach your full potential throughout your studies. You can call on a wide range of services and resources, all provided with expertise, professionalism and confidentiality.

If barriers are preventing you from integrating into university life and you need adaptive measures to progress (physical setting, arrangements for exams, learning strategies, etc.), contact:

- **(currently unavailable)** visiting the SASS Academic Accommodations office on the third floor of the Desmarais Building, Room 3172
- logging into the Academic Accommodations Portal (Ventus) and completing the intake form
- calling the SASS Academic Accommodations office at 613-562-5976

Deadlines for submitting requests for adaptive measures during exams:

- Midterms, tests, deferred exams: seven business days before the exam, test or other written evaluation (excluding the day of the exam itself
- Final exams:
  - November 15 for the fall session
  - March 15 for the winter session
  - Seven business days before the date of the exam for the spring/summer session (excluding the day of the exam itself).

Justification of absence from an examination (mid-term, final, supplemental or deferred) or from a test, or of late submission of assignments

Absence from any examination or test, or late submission of assignments on medical grounds or due to exceptional personal circumstances must be justified; otherwise, students will not be given the opportunity to complete the missed examination or test or to submit late assignments.

See regulation A-8 for more information...

Content Ownership

The materials you receive for this course are protected by copyright and to be used for this course only. You do not have permission to upload the course materials, including any lecture recordings you may have, to any website. If you require clarification, please consult your professor.

Regulation on Bilingualism at the University of Ottawa

Every student has the right to require that a course be given in the language used to describe the course in the course calendar (Academic Regulation A-1). Except in programs and courses for which language is a requirement, all students have the right to produce their written work and to answer examination questions in the official language of their choice, regardless of the course's language of instruction.

Notice of Collection of Personal Information for Recording of Lesson Capture

In accordance with the *Freedom of Information and Protection of Privacy Act in Ontario* and with University Policy 90, your personal information is collected under the authority of the University of Ottawa Act, 1965.

The Adobe Connect/Zoom/MS Teams sessions will be recorded for purposes consistent with the fulfillment of the course learning activities and outcomes. The recording may include the use of your name, appearance, image, voice and messages. If you are attending the lesson online and you choose not to have your image or audio recorded, you may disable the audio and video functionality within the recording platform. If you are attending the lesson in person and do not wish to be recorded, please contact your instructor the first week of class to discuss alternative arrangements.

The information collected in accordance with this notice will be retained for one year from the end of the semester.

If you have questions about the collection, use and disclosure of your personal information in this notice, please contact Instructor email. Questions of a general nature regarding the collection, use and disclosure of information should be addressed to the Chief Privacy Officer by email at aipo@uottawa.ca.

Student Services and Resources

[Academic Support](#)

The [Academic Support](#) hub is a one-stop shop for academic support. Whether you're an experienced student or just starting out, you'll find some great resources to help you succeed.

With the [Academic GPS](#), you can:

- chat with a mentor seven days a week;
- register for study groups;
- take part in study methods workshops (note taking, time management, exam preparation, stress management, Academic Integrity Session, etc.);
- book an appointment with a mentor.

[uOttawa Library](#)

Access the Library's Physical Collections

We are currently providing mediated access to the physical library collection through the following services:

- Contactless pickup
- Scan-on-demand
- Returns and renewals
- Course reserves

Changes to On-Campus Library Services

While the Library continues to offer services online, including remote access to specialized software and databases, we are also providing on-campus services like study spaces and computer workstations for both walk-ins and by reservation.

The services and operations of the library are updated often. Please check [our website](#) for the latest information.

[Health and Wellness](#)

Your wellness is an integral part of your success. If you don't feel well, it can be hard to focus on your studies. Dedicated professionals and fellow students who care about you are always ready to provide advice and support. Depending on your needs, many activities and services exist to accompany you during your academic journey.

Services include:

- opportunities to connect;
- counselling sessions;
- peer support;
- physical activity;
- wellness activities and workshops; spiritual guidance.

If you want to connect with a counsellor, [you can book an appointment online](#) or go to their walk-in clinic at **100 Marie-Curie, fourth floor**. You can also drop-in to our wellness space, chat online with a peer helper, or access 24/7 professional help through the website at https://www.uottawa.ca/wellness/.

Access Service

The [Academic Accommodations Service](#) tries to make sure all students with disabilities have equal access to learning and research environments, the physical campus and University-related programs and activities. The Academic Accommodations service works with other campus services to create an accessible campus learning environment, where students with disabilities have an equal opportunity to flourish. We offer a wide range of services and resources, provided with expertise, professionalism and confidentiality.

Some services we offer:

- Help for students with disabilities in making the transition;
- Permanent and temporary accommodation measures;
- Learning strategy development;
- Adaptive exams
- Transcriptions of learning material Interpretation (ASL and LSQ);
- Assistive technologies.

If you think that you might need any of our services or supports, [email the Academic Accommodations service (adapt@uOttawa.ca)](mailto:adapt@uOttawa.ca).

Note that the University of Ottawa is affiliated with [AERO](#) and [ACE](#) services for the adaptation of accessible academic materials for students with perceptual disabilities. If you have any questions, please contact the Accessibility Librarian ([libadapt@uottawa.ca](#)) or the [Academic Accommodation Services](#) for textbooks.

Human Rights Office

The mandate of the [Human Rights Office](#) is to provide leadership in the creation, implementation and evaluation of policies, procedures and practices on diversity, inclusion, equity, accessibility and the prevention of harassment and discrimination.

Contact information: 1 Stewart St. (Main Floor – Room 121) - Tel.: 613-562-5222 / Email: [respect@uOttawa.ca](#)

Career Services

[Career Services](#) offers various services and a career development program to enable you to recognize and enhance the employability skills you need in today's world of work.

GRADUATE ATTRIBUTES ASSESSMENT

CEAB Graduate Attributes	1	2	3	4	5	6	7	8	9	10	11	12
and Levels: I* ("introductory") D† ("developing) or A‡ ("advanced") to indicate level of expected achievement	D	D	I	D	D	D						

The following table is divided into three main sections

1) **Attributes†:** CEAB attributes covered and the level of expected achievement

I: Introductory, indicating students are working at a basic level, working with foundational elements, techniques or methodologies of the learning outcome

D: Developing, indicating students are learning how to perform the attribute at an intermediate level

A: Advanced/Applied, indicating students are learning how to perform the attribute as written at a level that is expected of someone who is completing their degree

2) **Indicators:** Indicators being covered as well as their description

3) **Learning Outcomes and Attribute Assessment Tools*:** Method for evaluating each learning outcome, using the following nomenclature

E: Test/Quiz/Exam
RI: Written Report, Individual
RG: Written Report, Group
PI: Project, Individual
PG: Project, Group
OI: Oral Presentation, Individual

OG: Oral Presentation, Group
AI: Assignment, Individual
AG: Assignment, Group
L: Lab Notebook/Portfolio
SP: Self or Peer Evaluation
O: Other (please specify)

CEAB Attribute Number†	Level	Description of Learning Outcomes (LO) and Assessment Tools* (AT)
1	D	**1.C) Demonstrate competence in specialized engineering knowledge appropriate to the program of computer engineering**
	LO:	1.C-5 Understand computer elements and fundamentals of computer organization
	AT:	E
2	D	**2.B) Demonstrate the ability to formulate a coherent model representation of an engineering problem**
	LO:	2.B-3 Decompose complex problems into simpler interconnected sub-problems and adapt models to sub-problems
	AT:	L
3	I	**3.D) Demonstrate an ability to investigate problems using experimentation.**

CEAB Attribute Number†	Level	Description of Learning Outcomes (LO) and Assessment Tools* (AT)
		LO: 3.D-2 Investigate the cause of different types of problems (defects, failures) encountered in software
		AT: E
4	D	**4.D) Develop, implement and experimentally validate the engineering design to reach a defined end state**
		LO: 4.D-4 Experimentally validate the performance of the implementation
		AT: RG
5	D	**5.A) Use fundamental techniques, resources and engineering tools**
		LO: 5.A-9 Develop small projects by using modern CAD environments and practically implemented on PLDs or FPGAs
		AT: O: assessment of in-lab activity
6	D	**6.C) Demonstrate success in a team-based project work environment**
		LO: 6.C-1 Complete a project successfully in terms of technical requirements, deadlines, regulatory constraints, and overall satisfaction of team members
		AT: RG
7	I	
	LO	
	AT	
8	I	
	LO	
	AT	
9	I	
	LO	
	AT	
10	I	
	LO	
	AT	
11	I	
	LO	
	AT	
12	I	
	LO	
	AT	

†Graduate Attribute and Indicator Cross Reference given below

1. A knowledge base for engineering: Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

2. Problem analysis: An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions

3. Investigation: An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions

4. Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

5. Use of engineering tools: An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

6. Individual and team work: An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

7. Communication skills: An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

8. Professionalism: An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

9. Impact of engineering on society and the environment: An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

10. Ethics and equity: An ability to apply professional ethics, accountability, and equity.

11. Economics and project management: An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.

12. Life-long learning: An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.