Chemistry
UNIVERSITY OF TORONTO

CHM1106H: Laboratory Instrumentation

Course Syllabus – Winter 2022

I TEACHING TEAM

INSTRUCTOR:
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* Student hours will typically be in person, but can be delivered online on an *ad hoc* basis – contact the instructor to schedule this when needed

Pandemic Update. ***The details in this shaded box (which are focused on virtual course activities) supersede all other information in this syllabus, especially those sections that mention "in person" activities.*** As you know, the university has decreed that course activities can only be delivered online in January 2022. For this course, this means that the six classes/student hours scheduled to take place in January (Jan. 11, 13, 18, 20, 25, & 27) will be held synchronously by Zoom at https://utoronto.zoom.us/j/88228546111 with password 'instrument' instead of being delivered in person. (These classes will also be recorded and will be available for asynchronous viewing.) Likewise, Laboratory Exercise 1 (Jan. 20) will be run as an online "demo" (instead of being participatory and in-person) and will be recorded for asynchronous viewing. The format for course activities planned for February-April (including classes, student hours, tests, and laboratory exercises) has not yet been determined – if we are permitted to meet in-person, we will do so, but if this is not allowed, we will engage online (check the course website regularly for updates). Most importantly, regardless of format, ***all of the activities for this course that are scheduled for Feb-Apr will take place at the times and on the dates described in this syllabus.***

II COURSE OVERVIEW

COURSE DESCRIPTION:
This course is unique in the Chemistry canon in that it provides practical background useful for understanding, repairing, and building simple (and not-so-simple) instrumentation that is ubiquitous in the modern analytical laboratory. On the subject of electronics, the course covers voltage and current, resistors, capacitors, inductors, diodes, transistors, op-amps, digital electronics, and microprocessors. On the subject

of computer programming, the course covers an introduction to programming, flowcharts, algorithms, C++ syntax, variables, functions, serial communication, and data processing. Finally, on the subject of optics, the course covers light sources, wavelength selectors, detectors, lenses, mirrors, prisms, polarizing optics, microscopy, and non-linear optics. The course includes a series of unique laboratory exercises to give you an opportunity to gain experience with the concepts and subjects discussed in the classes.

STUDENT LEARNING OUTCOMES:
At the end of this course, successful students will be able to:

- inspect circuit diagrams and understand the role(s) of the electronic components found therein
- read C++ programs intended for operating Arduino microcontrollers and to be able to predict the results upon execution
- inspect optical-bench components and determine their functionality and understand the rationale for their use
- design, build, and trouble-shoot simple electronic circuits appropriate for use in laboratory instrumentation
- write and debug C++ programs (with suitable documentation) appropriate for operation and control of Arduino microcontrollers
- design, build, and align optical systems appropriate for use in laboratory instrumentation

READINGS:
There is no formal text for this course – the content that you are responsible for will be presented in classes, labs, and problem-sets. References that may be useful for independent study include:

- *Principles of Instrumental Analysis* by Skoog, Holler, and Nieman
- *The Art of Electronics* by Horowitz and Hill
- *Optics* by Hecht
- *Building Scientific Apparatus* by Moore, Davis, and Coplan
- *Code Complete* by McConnell
- *Programming Arduino* by Monk
- *C++ Primer* by Lippman (advanced reading)
- *Python Crash Course* by Matthes (advanced reading)
- Physics concepts: http://hyperphysics.phy-astr.gsu.edu/hbase/HFrame.html
- Electrical circuit concepts: http://www.allaboutcircuits.com/
- Electrical circuit emulators: http://falstad.com/circuit, https://www.ti.com/tool/TINA-TI
- Arduino simulator: https://www.tinkercad.com
- Introduction to/examples for Arduino: https://playground.arduino.cc/
- Introduction to Light Microscopy: http://www.microscopyu.com/

III COURSE ORGANIZATION

CLASS TOPICS & SCHEDULE:
Classes will be held in-person on Tuesdays and Thursdays from 3:00 – 4:00 PM Eastern Time Zone in Lash Miller Room 155, beginning on Jan. 11th and ending on Apr. 7th. As the course progresses, we will discuss three units of material, with each unit (listed below) corresponding to a class notes file (for Units 1 & 3) or a series of 'activities' in tinkercad.com (for Unit 2). Each file or URL will be posted to the course website prior to the corresponding classes, and will be addressed chronologically throughout the semester – specifically, Unit 1 (electronics) in Jan-Feb, Unit 2 (programming) Feb-Mar, and Unit 3 (optics) in Mar-Apr. Each unit is associated with multi-part problem sets (or their equivalents), two laboratory exercises, and a term test or an exam. ***Note: please bring a wireless-networkable laptop to the "Unit 2" classes on Feb. 10, 15, and 17, and March 1, 3, 8, and 10 to participate in in-class programming activities. Let the instructor know if you do not have access to a laptop.***

Unit 1: Electronics for the Laboratory
Unit 2: Computer Programming for the Laboratory
Unit 3: Optics for the Laboratory

COURSE WEBSITE:
The most detailed and up-to-date information about the course is posted on the course website, which can be found by logging in to your Quercus account at https://q.utoronto.ca. You are advised to check the course website often, as content (summarized below) will be updated regularly.

- Syllabus and Course Schedule
- Announcements
- Lecture Notes and Tinkercad.com Links
- Problem Sets and Keys
- Old Tests and Keys
- Lab Exercise Information Sheets
- Term Tests and Keys

IV EVALUATION/GRADING SCHEME

OVERVIEW:
Two Term Tests and Final Exam: 100%

MARKING SCHEME & DATES/TIMES:
Your mark in this course comes from two term tests and the final exam. The dates for these assignments are given in the table below. ***There will be no "make-ups," so record these dates and times now and plan to participate accordingly.*** Each test/exam will cover the material in one of the three units in the course, and thus has (nominally) the same 'weight' or 'importance.' But because anyone can have a bad day (and can make a bad mark on that day), your final mark will be calculated as 45% - test/exam with your highest score, 45% - test/exam with your second-highest

score, 10% - test/exam with your lowest score. For example, if you score a 90, a 70, and a 50 on the tests/exam, your final mark will be a 77.

In addition, there will also be six voluntary laboratory exercises, which will provide important context to support the concepts covered in the class materials. These will occur on Thursday evenings throughout the semester – see table below.

Assignment	Date and Time (all times Eastern)
Term Test 1 (synchronous, in person)	Thursday, February 10, 6:00 – 8:00 PM, Place TBD
Term Test 2 (asynchronous, open book)	Assigned Thursday, March 10 at 5:00 PM, Due Thursday, March 17 at 5:00 PM
Final Exam (synchronous, in person)	April Final Assessment period, Place, Date, and Time TBD
Laboratory Exercises (synchronous, in person)	Thursdays 6:00 – 8:00 PM on January 20, February 3, February 17, March 10, March 24, April 7 in Lash Miller Room 206

TERM TESTS AND EXAM:
There are two term tests and one exam, each corresponding to one of the course units. The first test is on February 10 (to be completed synchronously and in person from 6:00 - 8:00 PM Eastern Time), and the second is due March 17 (to be completed asynchronously and then submitted electronically by 5:00 PM Eastern Time). The exam has not been scheduled but will occur during the April Final Assessment period (after the final class). Failure to participate in tests/exams will result in a grade of 'zero'; the only acceptable excuse is an illness or other medical emergency, as addressed below. In such cases, there will be no "makeup assignments"; the instructor will work with you to determine a fair reapportionment of the other marked materials.

LABORATORY EXERCISES:
This course features six 2-hour laboratory exercises, scheduled for select Thursdays throughout the semester (Jan. 20, Feb. 3, 17, March 10, 24, April 7) from 6:00 – 8:00 PM Eastern Time in Lash Miller Room 206. Lab Information sheets will be posted on Quercus before each date; be sure to review them and bring either digital or hard copies to the lab. (It is also advisable to bring a personal laptop to each exercise.) The exercises will guide you to build a proto-instrument to measure fluorescence from the contents of a capillary, similar what is commonly found in capillary zone electrophoresis instruments. At the beginning of the semester, students will divide into teams of 5-6; each team will then work together for the duration of the semester to build 'their' proto-instrument. The lab exercises are not mandatory, and no marks will be assigned to them. But experience from previous years has suggested that students find the exercises exceedingly useful for reinforcing and providing context for the concepts and ideas that appear on term tests and exams.

PROBLEM SETS AND OLD TESTS/EXAMS:
On Quercus, you will find multi-part problem sets and keys, each corresponding to one of the course units. Note that problem-sets are in PDF form (appropriate to print and complete manually) for Units 1 & 3, and there are online 'activities' assigned via

tinkercad.com for Unit 2. (The latter will be partly/wholly worked through during the relevant class periods but will also be available for you to revisit for tinkering and studying at any time during the semester). The problem sets will not be collected or marked, but working through them is highly recommended to prepare for the tests/exam. Likewise, a set of old tests/exams and keys has been posted, which may also be useful for preparation, but note that the format for the tests that were administered during previous semesters of 'online learning' will be quite different than the format that will be used this year.

V COURSE POLICIES

GENERAL:
The University of Toronto is committed to equity, human rights and respect for diversity. All members of the learning environment in this course should strive to create an atmosphere of mutual respect where all members of our community can express themselves, engage with each other, and respect one another's differences. The course instructor will neither condone nor tolerate behaviour that undermines the dignity or self-esteem of any individual in this course and wishes to be alerted to any attempt to create an intimidating or hostile environment. It is our collective responsibility to create a space that is inclusive and welcomes discussion. Discrimination, harassment and hate speech will not be tolerated. If you have any questions, comments, or concerns, you are encouraged to reach out to the staff in the university's Equity Offices.

EXPECTATIONS:
Each member of this course is expected to maintain a:

- professional and respectful attitude during all course activities, including classes, tests/exams, laboratory exercises, and online activities
- personal calendar/schedule/organizer to ensure that all course activities are completed, and due dates are met
- collection of notes recorded independently based on concepts covered in course activities (students registered with Accessibility Services requiring a class note-taker will have access to this accommodation)
- familiarity with the university policy on Academic Integrity

ABSENCES
The in-person classes and laboratory exercises will (generally) not be recorded and will not be available asynchronously. You are advised to attend them, but attendance is not required. On the other hand, participation completion of the term tests and the exam is mandatory; absences are only excusable because of illness or other emergency. In such a case, ***before the date/time that the assignment is due***, you must (i) inform the instructor by email or other means, and (ii) declare the absence using the "Absence Declaration Tool" on ACORN (https://www. acorn.utoronto.ca/) which is found in the "Profile and Settings" menu. In such cases, there will be no "makeup assignments" or credit awarded for "late" submissions; instead, the instructor will work with you to determine a fair reapportionment of the other marked materials.

VI TECHNOLOGY REQUIREMENTS

This course requires the use of computers, and technical challenges are possible. When completing academic work, students are responsible for scheduling enough time to allow for reasonable delays due to technical difficulties to be overcome, so such issues will not be acceptable grounds for deadline extension. Particularly, maintaining an up-to-date independent backup copy of your work is strongly recommended to guard against hard-drive failures, corrupted files, lost computers, etc. Specific guidance from the U of T Vice-Provost, Students regarding student technology requirements is available here: https://www.viceprovoststudents.utoronto.ca/covid-19/tech-requirements-online-learning/, and advice for students more broadly regarding online learning is available here: https://onlinelearning.utoronto.ca/getting-ready-for-online/.

VII INSTITUTIONAL POLICIES & SUPPORT

ACADEMIC INTEGRITY:
You are encouraged to discuss course content and to work problem-sets and old tests with your classmates, and to work together to complete and understand the laboratory exercises. ***However, the assignments that will be graded in this course (including the two term tests and the final exam) must be completed by you and you alone, according to the university's policies on academic integrity.*** Academic integrity is essential to the pursuit of learning and scholarship in a university, and to ensuring that a degree from the University of Toronto is a strong signal of each student's individual academic achievement. As a result, the University treats cases of cheating and plagiarism very seriously. The University of Toronto's Code of Behaviour on Academic Matters (https://governingcouncil.utoronto.ca/secretariat/policies/code-behaviour-academic-matters-july-1-2019) outlines the behaviours that constitute academic dishonesty and the processes for addressing academic offences. Potential offences include, but are not limited to:

- Using someone else's ideas or words without appropriate acknowledgement
- Submitting your own work in more than one course without the permission of the instructor
- Making up sources or facts
- Obtaining or providing unauthorized assistance on any report
- Using websites (such as Chegg.com) to post course material/questions/answers
- Looking at someone else's answers or collaborating/discussing during a test
- Misrepresenting your identity
- Falsifying institutional documents or grades
- Falsifying or altering any documentation required by the University

All suspected cases of academic dishonesty will be investigated following procedures outlined in the Code of Behaviour on Academic Matters. If you have questions or concerns about what constitutes appropriate academic behaviour or appropriate research and citation methods, you are expected to seek out additional information

on academic integrity from your instructor or from other institutional resources (see https://www.academicintegrity.utoronto.ca/).

COPYRIGHT:
If a student wishes to copy or reproduce course notes or other course materials (outside of standard use for course activities), he or she must obtain the instructor's written consent beforehand. Otherwise, all such reproduction is an infringement of copyright and is absolutely prohibited. More information regarding this is available here: https://teaching.utoronto.ca/ed-tech/audio-video/copyright-considerations/.

ACCESSIBILITY NEEDS:
Students with diverse learning styles and needs are welcome in this course. The University of Toronto is committed to accessibility: if you require accommodations for a disability, or have any other accessibility concerns about the course, please contact Accessibility Services as soon as possible.

ACCOMMODATIONS FOR RELIGIOUS OBSERVANCES:
Following the University's policies, reasonable accommodations will be made for students who observe religious holy days that coincide with the due date/time of an assignment. Students must inform the instructor ***well before the assignment date*** to arrange accommodations.

ADDITIONAL SERVICES & SUPPORT:
- Full library service through University of Toronto Libraries
- Resources on conducting online research through University Libraries Research
- Resources on academic support from the Academic Success Centre
- Learner support at the Writing Centre
- Information for Technical Support/Quercus Support

ACKNOWLEDGEMENT OF TRADITIONAL LANDS:
The Teaching Team acknowledges the land on which the University of Toronto operates. For thousands of years, it has been the traditional land of the Huron-Wendat, the Seneca and, most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.