CHM 1106S – Lab Instrumentation
Winter 2021

Course Staff:

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Lectures and Office Hours: Lectures will be given virtually and synchronously via 'Bb Collaborate' on Tuesdays and Thursdays from 3:00 PM – 4:00 PM (Eastern Time Zone), beginning on Jan. 12th and ending on April 8th. A recording of each lecture will be available asynchronously shortly after it is completed. Office hours will also be given virtually and synchronously via Bb Collaborate (without recording) in the hour that immediately follows each virtual lecture (i.e., on Tuesdays and Thursdays from 4:00 PM – 5:00 PM, Eastern Time Zone) or by appointment.

Recordings of lectures (and other course materials) belong to the course staff, the University, and/or other sources, and are protected by copyright. Do not download, copy, or share any recording (or other course material) without the explicit permission of the course staff. For questions about recording and use of videos in which you appear please contact the course staff.

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 introduction to computer programming, flowcharts, Python syntax, variables, functions, algorithms, data processing, Jupyter notebooks (Google Colaboratory), and image 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 lectures; this year, the exercises will be delivered via a combination of in-person and virtual work.

Student Learning Outcomes: By the end of this course, you will be familiar with electronics and optics components that are used in the modern research laboratory, as well as the computer programs that are used to control them. You will have explored how these components and programs can be used together to collect measurable chemical analysis signals, and will be ready to apply this experience in practical settings, whether they be in the academic research laboratory, the industrial research laboratory, or anywhere in between.

Reference Materials:
There is no formal text for this course – the content that you are responsible for will be presented in lectures, 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
- *Python Crash Course* by Matthes
- Physics concepts: http://hyperphysics.phy-astr.gsu.edu/hbase/HFrame.html
- Electrical circuit concepts: http://www.allaboutcircuits.com/
- Electrical circuit emulator: http://www.falstad.com/circuit/
- Introduction to/examples for Arduino: https://playground.arduino.cc/
- Introduction to/examples for Python: https://www.w3schools.com/python/
- Introduction to Light Microscopy: http://www.microscopyu.com/

Prerequisite Courses: This course assumes you have a basic familiarity with analytical chemistry techniques for instrumental analysis. For students at the St. George campus, this typically means successful completion of CHM317H, but exceptions may be granted by the instructor.

Units and Lecture Notes: The course is organized in three units, covering topics related to electronics (Jan.-Feb.), computer programming (Feb.-Mar.), and optics (Mar.-Apr.). At least one virtual lecture-notes file will be posted to the course website to accompany each unit of lectures. You are encouraged to download these files and to use them to prepare for problem sets, laboratory exercises, and tests. For virtual participation in the lectures in units 1 and 3, any computing device (e.g., laptop, desktop, tablet, smart-phone), will suffice. But for the lectures in unit 2 (computer programming), you are advised to use a laptop or a desktop computer to get the most out the experience.

Course Website: The course website 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 will be updated regularly. Content to be posted on the course website is summarized below:

- Syllabus and Course Schedule
- Lectures (via Bb Collaborate)
- Lecture Notes
- Problem Sets and Keys
- Old Tests and Keys
- Lab Exercise Handouts
- Tests and Keys

Most of the files above are hosted directly on Quercus and can be opened online or downloaded to your local device, but some of the materials for unit 2 are hosted on google colaborate (https://colab.research.google.com/).

Marking Scheme: Your mark in this course will come from three tests (90%) and from participation in the laboratory exercises (10%); 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 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 40% - test with your highest score, 40% - test with your second-highest score, 10% - test with your lowest score, plus 10% - lab participation. For example, if you score a 90, a 70, and a 50 on the tests and have a perfect score for lab participation, your final mark will be a 79.

Assignment	Date and Time (all times Eastern)
Term Test 1	Synchronous: February 9, 3:00 – 4:00 PM
Term Test 2	Asynchronous: March 11, 5:00 PM – March 18, 5:00 PM
Term Test 3	Synchronous: TBD (after final lecture)
Laboratory Exercises	Synchronous: 6:00 – 8:00 PM on January 21, February 4, February 25, March 11, March 25, April 8

Tests: There are three tests in this course, each corresponding to one of the course units. The first test is on February 9 (to be completed synchronously from 3:00 - 4:00 PM Eastern Time via Quercus), and the second is due March 18 (to be completed asynchronously and then submitted by email by 5:00 PM Eastern Time). The third test has not been scheduled but will be delivered synchronously via Quercus on a date and time after the final lecture on April 8. Failure to participate in tests will result in a grade of 'zero'; the only acceptable excuse is an illness or other medical emergency, as addressed below.

Problem Sets and Old Tests: You are encouraged to download problem sets that are posted to the course website and correspond to the course units. The problem sets will not be collected or marked, but working them is highly recommended to prepare for the tests. Likewise, a set of old tests and keys will be posted to the course website, which may also be useful for preparation, but note that the format for the synchronous tests this year (which will be given online) will be different than what was given in previous years.

Laboratory Exercises: This course features six 2-hour laboratory exercises, scheduled for select Thursdays throughout the semester (Jan. 21, Feb. 4, Feb. 25, Mar. 11, Mar. 25, Apr. 8) from 6:00 – 8:00 PM Eastern Time. 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, with one graduate student per team; each team will then work together for the duration of the semester to build 'their' proto-instrument. Handouts will be issued (via the course website) in advance of each of the six exercises, and each team is encouraged to meet virtually to discuss the contents prior to the day of the activity. In practice, the graduate student in each team will participate in the lab exercise in person (to build the proto-instrument), while undergraduate students will participate virtually (suggesting steps to take toward building the proto-instrument). Both roles are equally important, and participation marks (cumulative, for all of the exercises) will be assigned at the end of the semester.

> **Undergraduate Student (CHM417) Virtual Laboratory Instructions.** On the day of the exercise, log in to Bb Collaborate and join your team's designated 'room' at 6:00 PM, ready to work with your in-person teammate to carry out the steps involved in the exercise. The more back-and-forth communication with the rest of your team, the higher the participation score will be.
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> **Graduate Student (CHM1106) In-Person Laboratory Instructions**. On the day of the exercise, meet the course staff in Lash Miller room 206 at 6:00 PM, ready to comply with the U of T COVID-19 Safety Plan for In-Class learning (https://ehs.utoronto.ca/wp-content/uploads/2020/11/COVID-19-Safety-Plan-for-In-class-instructions_FINAL.pdf). You should bring a laptop equipped with a working web-camera, which will be used to (a) control the proto-instrument that is being developed in the exercise, and (b) project your actions to team-members who are participating virtually. If you do not have access to a laptop (either a personal computer or one belonging to your research laboratory), please inform the course staff immediately, so that alternate arrangements can be made. During the exercise, you will maintain communication with the rest of your team as you decide what steps to take. The more back-and-forth communication with the rest of your team, the higher your participation score will be.

Absences: You are advised to participate in the virtual lectures, but attendance will not be marked or collected. On the other hand, participation in the synchronous tests and submission of the asynchronous test by the due date/time is mandatory; absences are only excusable because of illness or other medical emergency. In such a case, ***before the date/time that the assignment is due***, you must (i) contact the instructor by email or other means, and (ii) declare the condition using the "Absence Declaration Tool" on ACORN (https://www. acorn.utoronto.ca/) which is found in the "Profile and Settings" menu. Participation in the laboratory exercises is voluntary (and there is no need to declare them), but note that participation marks will be collected.

Online Considerations: 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/. This course requires the use of computers, and of course sometimes things can go wrong when using them. You are responsible for ensuring that you maintain regular backup copies of your files, use antivirus software (if using your own computer), and schedule enough time when completing an assignment to allow for delays due to technical difficulties. Computer viruses, crashed hard drives, broken printers, lost or corrupted files, incompatible file formats, and similar mishaps are common issues when using technology, and are not acceptable grounds for a deadline extension.

As we engage with each other online, please consider the University's statement on etiquette: “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. U of T does not condone discrimination or harassment against any persons or communities.”

Academic Integrity: You are welcome (and encouraged) to discuss course content and to work problem-sets and old tests with your classmates. But the tests should 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; this is particularly important during the pandemic, in which our interactions are largely (or completely) online. 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 the items in the lists on the following page.

In papers and assignments:

1. Using someone else's ideas or words without appropriate acknowledgement
2. Submitting your own work in more than one course without the permission of the instructor
3. Making up sources or facts
4. Obtaining or providing unauthorized assistance on any assignment

On tests and exams:

1. Using or possessing unauthorized aids
2. Looking at, copying, or discussing another student's answers for synchronous or asynchronous tests prior to submission
3. Misrepresenting your identity

In academic work:

1. Falsifying institutional documents or grades
2. 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/).