

# PHYS333 - Introductory Quantum Computing

## Spring 2026

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**Professor:** Rogério de Sousa

This course, targeted at both 2<sup>nd</sup> and 3<sup>rd</sup> year undergraduate students in science and engineering (including computer science and software engineering) teaches the basics of quantum computation and information.

The student will get to submit jobs to cloud-based quantum computers provided by IBM-Q using a Python-based interface.

## Prerequisites

MATH211 or MATH110 (Matrix algebra).

Some experience with computer programming.

No background in quantum physics or Python is needed, although some familiarity with Python will be useful.

## Lectures

Tue, Fri: 2:30pm - 3:50pm, **in-person**

All lecture materials and assignments are available in the course's Brightspace:

<https://bright.uvic.ca/d2l/home/432643>

Lectures will also be broadcast in zoom to accomodate special situations such as sickness and travel. However, videos of past lectures will not be made available except under special circumstances. This is being done because in-person attendance is strongly recommended for this course. We will engage on group activities that make problem solving productive and fun, greatly enriching the learning experience.

Attendance is not required, but is strongly recommended.

All lecture boards are available online; you will find them under "Live lecture boards" in the content link.

## Office hour

Wednesdays, 12:30pm-3:00pm. In-person at my office (Elliott 117) and synchronously in my [private Zoom room](#).

## How to ask questions about content, assignments, etc

Use our [P333 Discussion Forum - Questions about the course, assignments, etc](#).

I give up to 10% bonus to the final grade for students who actively participate in class and in the forum.

Each of the 6 assignments carries 1% bonus associated to forum participation (6% total). For each assignment, you can get:

- 0.25 % for each question you ask;
- 0.50 % for each question you answer correctly;
- 1.00 % for an answer that I judge to be exceptional for the class.

I will also give extra credit for class participation. This will amount to 4% on the final grade depending on whether I felt that you asked questions and interacted with me and the class during the lectures.

Whenever you have questions about the material taught, please send messages or questions using the UVic brightspace forum. That way all students will have access to our conversation.

If you wish to send me a private message, please send it to my UVic email: [rdesousa@uvic.ca](mailto:rdesousa@uvic.ca) .

## Textbook

I do not follow a specific textbook in my course. In fact, the lecture boards become the textbook. Unfortunately there is currently no textbook teaching the selection of materials I have. The one listed below is free (for UVic students) and gets the closest to the material I intend to teach. It can be used to give a different perspective on what I am teaching.

**A First Introduction to Quantum Computing and Information**, Bernard Zygelman (Springer Nature AG Switzerland, 2018).  
This is an eBook: You can [download a free .pdf copy](#) from the University of Victoria library.

Other suggested books, videos, websites:

- "Quantum Computation and Quantum Information", Michael A. Nielsen and Isaac L. Chuang (Cambridge University Press, U.K. 2000). This book is often referred to as the "Bible" of the field. While it is self contained, it is aimed at graduate students.
- "Quantum Computing: A beginner's introduction", Parag K. Lala (McGraw-Hill Education, New York, 2019).
- "Canadian Summer School on Quantum Information" (video), [https://www.youtube.com/watch?v=Q4xBISi\\_fOs](https://www.youtube.com/watch?v=Q4xBISi_fOs)
- "Quantum Information for Developers", ETH-Zurich (Lecture notes and videos), <https://qid.ethz.ch/>

## Topics to be covered

### Part I: Fundamentals

Survey of quantum physics: Stern-Gerlach experiment and the spin of the electron, analogy with polarization states of light. Linear algebra with complex numbers and Dirac's notation. Inner products, tensor products, adjoint operation. Operators as square matrices, basis change. Hermitian and normal (diagonalizable) operators. Unitary operators.

Quantum theory: State space, observables, projections, and quantum measurement. Pauli matrices and their eigenstates. Expectation value of observables. Representing single qubit states in the Bloch sphere. Entangled states.

<p><b>Part II: Quantum Computation</b></p> <p>Quantum circuits: One-qubit operations (Pauli, Hadamard), controlled two-qubit operations, measurement. How to draw quantum circuits and relate to matrix representation. Circuit that generates Bell states. Irreversibility and universality for classical gates. Universality for quantum gates. How to program a quantum oracle that evaluates 1-bit Boolean functions.</p> <p>Elementary quantum algorithms and quantum speed-up: Deutsch and Deutch-Josza, quantum parallelism. Bernstein-Vazirani, Simon's algorithms.</p> <p>Quantum cryptography with BB84. Elementary quantum tomography. No-cloning theorem, quantum teleportation. Elementary 3-qubit error correction.</p>
<p><b>Part III: Hands-on with IBM-Q and applications</b></p> <p>Overview of Jupyter Hub. IBM Qiskit tutorials and simple examples. Composing quantum circuits and running them in simulators and real devices. Comparisons between simulations and experiments, quantum depth, noise. Elementary phase estimation (without quantum Fourier transform). Classical simulation of quantum circuits, Clifford circuits.</p> <p>Introduction to the RSA (Rivest-Shamir-Adleman) public-key cryptography system for secure data transmission. Elementary group theory and its connection to RSA. RSA encryption with two large primes. Vulnerability to a period-finding machine . Using a Quantum Computer to hack RSA. Shor's algorithm to hack RSA and to factor large numbers.</p>

## Grading scheme

Assignments	20%
Midterm	30%
Final	50%

## Assignments

There will be 6 assignments. All assignments are already posted on this website, with noted due dates on either Tuesdays or Fridays at 6pm, e.g. [P223 - Assignment 1 \(A1\)](#) is due Friday Jan. 16.

Assignment solutions will be available online a few days after the due date.

The assignments will be graded by Teaching Assistant Negar Seif. Any questions on grading should be addressed directly to them by email, at [negarseif@uvic.ca](mailto:negarseif@uvic.ca).

# Midterm exam

Feb. 13th (Friday), in-class, 2:30 pm - 3:50pm.

## Notes on the exams

- On all examinations the only acceptable calculator is the sharp EL-510R. This calculator can be bought in the bookstore for about \$20.
- You are allowed one 8.5X11" handwritten formula/note sheet. **You can only write on ONE side of the sheet: I am doing this because some people were copying assignment solutions to the formula sheet, a habit that should be discouraged.** You will be responsible for the "usual" definitions and equations that we have dealt with in class on a regular basis.

# Final letter grade: UVic's percentage grading system

A+	90-100	Exceptional performance.
A	85-89	Outstanding performance.
A-	80-84	Excellent performance.
B+	77-79	Very good.
B	73-76	Good.
B-	70-72	Solid.
C+	65-69	Satisfactory.
C	60-64	Minimally satisfactory.
D	50-59	Marginal performance.
F	0-49	Unsatisfactory performance.

# How to succeed

- Attend classes and office hours in-person;
- Most important: **Attempt the assignments by yourself, without looking at solutions first.** If you can't solve a problem, talk to your classmates, or attend the office hour. However, it is extremely important that you attempt to solve the problem by yourself first. Experience shows that students who copy solutions from others usually perform very poorly in the exams and fail the course.
- Common mistake: Some students do not study/review the board/notes/book before attempting the assignments. Instead, they "pick" their notes trying to find the material needed to solve a particular problem. Such method does not work because it leads to fragmented knowledge; the student does not understand the connection between the topics. Moreover, studying that way does not prepare for the exam, because there will be no book or notes to "pick" during the exam.
- Suggestion on how to study: Do a subject review before attempting the assignment, by reading the board/book/notes.

Start by reading the assignment fully, and then attempt the problem that appears to be easier (it is okay to briefly go back to the book or notes during the assignment).

- Solve extra problems to practice for the exams.