ACKNOWLEDGEMENT

UBC's Point Grey Campus is located on the traditional, ancestral, and unceded territory of the xwməθkwəy̓əm (Musqueam) people. The land it is situated on has always been a place of learning for the Musqueam people, who for millennia have passed on their culture, history, and traditions from one generation to the next on this site.

COURSE INFORMATION

Course Title	Course Code Number	Credit Value
Numerical Methods for Differential Equations Topics in Numerical Analysis	MATH405 MATH607E	3 credits

PREREQUISITES

Some background in differential equations: e.g. one of
MATH 256, MATH 257, MATH 316, MATH 358, MECH 358, PHYS 312

COREQUISITES

none

CONTACTS

Course Instructor(s)	Contact Details	Office Location	Office Hours
Christoph Ortner	**TBA** Please use email ortner@math.ubc.ca only in exceptional circumstances	LSK 303	Mon 1330-1430 Wed 1100-1200

OTHER INSTRUCTIONAL STAFF

TA - Ruo Ning Qiu

COURSE STRUCTURE

The course will be taught through in-person lectures using mixed media, including slides for core content, extensive computational experiments, and some blackboard/whiteboard/tablet for more theoretical topics and discussions. Most aspects of the course will involve a combination of algorithm design, theory and implementation. The language will be Julia through Jupyter notebooks. It will be possible to use personal computing equipment or use a Jupyter hub provided by the Mathematics department and used purely through a web interface.

SCHEDULE OF TOPICS

[1] Basics

- Linear Sytems, LU factorisation, eigen decomposition, Hermitian matrices
- Nonlinear systems, iterative solution, Newton's method, bisection, fixed point iteration
- Floating point arithmetic
- Polynomial interpolation, quadrature (Bonus: Weierstrass approximation theorem)

[2] Ordinary Differential Equations
- Numerical solution of initial value problems, Runge Kutta method
- Stability, stiff problems, explicit vs implicit integrators
- Structure-preserving numerical integrators, Hamiltonian systems
- Two-point boundary values problems

[3] Partial Differential Equations
- Review of Fourier analysis
- Diffusion equations
- Advection equations

[4] Bonus Material: examples of what we might cover if there is time
- spectral methods, Paley Wiener theorems
- 2d and 3d boundary value problems
- Large linear systems, Krylov methods, Multi-grid methods, Preconditioning
- Finite element methods
- Monte-Carlo methods
- Artificial Neural Networks

LEARNING OUTCOMES

The overarching goal of this course is to provide students with a foundation towards (i) becoming "power users" of modern simulation techniques; and towards (ii) advanced training in numerical analysis. This is achieved by introducing the fundamentals of numerical simulation hand-in-hand with use of existing software as well as their own software implementation. At the end of this course, students will have aquired a solid foundation from which to build their expertise in numerical simulation in order to make informed decisions about numerical schemes for different problems, to adapt existing schemes or develop new schemes where necessary.

In concrete terms, the course will introduce the basic numerical techniques for solving ordinary and partial differential equations in a self-contained course requiring no previous numerical analysis background.

LEARNING MATERIALS

Slides (Jupyter notebooks), written notes, references to textbooks, example codes in Julia.

Although we will not follow it precisely, the following reference gives a good indication of the course style and content: https://fncbook.github.io/fnc/frontmatter.html.

Further examples of suitable textbooks will be provided during the course.

ASSESSMENTS OF LEARNING

The assessment will test theoretical understanding, mathematical skills, computational skills, as well as communication. Regarding the final point, it is important for advanced students to be able to explain their reasoning, which will be tested through presentations.

MATH 405: 50% written assignments, 10% midterm, 10% group project, 30% final

Midterm: 28/10

The value of one assignment (10%) or of the midterm can be shifted to the final – more details below.

MATH 607: 50% written assignments, 50% project (30% report, 20% presentation)

Details:

(1) There will be **5 assignments**, with a mix of theory and computation, submitted as Jupyter notebooks. Answers to theory questions must be typeset in LaTeX. The precise mechanics of obtaining and submitting the assignments (Canvas) will be explained in class.
Note that Assignment 0 + Assignment 1 will be combined for the purpose of grading.

(2) Late assignments will receive 0%. There will be no exceptions. You will be given plenty of time to complete the assignments, so please manage your time well.

(3) Nevertheless, sometimes there are unforeseen circumstances, hence it is possible to shift either one assignment or one midterm to the final which will then be worth 40%. This does not require a formal concession; instead the final grade will be automatically optimized for all students. E.g. if a student misses an assignment/midterm or scores lower than in the final, the score from that assignment/midterm will be ignored and the final will be increased to 40%. If the assignement and midterm scores are all higher than the final the distribution will remain as stated above.

(4) The **group project** will be undertaken in groups of three that will be randomly assigned. There will be some freedom in choice of project topic and date of presentation. Project presentations will be in the second half of term. Details and rubrics will be published in due course.

(5) **The Midterm exam** will be take place at the end of October. It will be based on theory and pseudocode (no actual code needs to be written). The scope will be all of Part [1] Basics and in addition Numerical solution of initial value problems and the Runge Kutta method.

(6) **607E only :** Topics for **graduate projects** will be chosen in consultation with the instructor around week 5-7 of the course. The project should contain theoretical and practical aspects, go well beyond the material of the course, and could be related to the student's thesis work.

UNIVERSITY POLICIES

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom. UBC provides appropriate accommodation for students with disabilities and for religious observances. UBC values academic honesty and students are expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions.

Details of the policies and how to access support are available on **the UBC Senate website.**