Course Information

Course Title	Course Code Number	Credit Value
Numerical Methods for Differential Equations	MATH 405 & MATH 607	3 credits

Prerequisites

Some background in differential equations: 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	Canvas and Piazza; email in exceptional circumstances: ortner@math.ubc.ca	tba	tba

Other Instructional Staff

none

Course Structure

The course will be taught through

- weekly live lectures
- weekly workshops
- recorded lectures e.g. on longer and more difficult proofs.
- directed group work with presentations during the workshops.

All aspects of the course will involve a combination of algorithm design, theory and implementation. The language will be JULIA through Jupyter notebooks. Installation on private machines will be beneficial, but I also hope to be able to setup a Jupyter server, which will allow students to work purely through a web interface.

SCHEDULE OF TOPICS

The order of presentation is subject to change. The core material is the minimal content that will be covered. *Further topics* will be covered depending on progress; I expect to cover at least fast linear solvers and spectral methods. All topics involve a mix of algorithm design, analysis of errors and performance, and implementation.

Core Material:

- Direct solution of linear systems
- Approximation of functions and numerical quadrature
- Iterative solution of nonlinear systems
- Numerical solution of ODEs
- Numerical solution of PDEs
  - finite difference discretisation
  - diffusion
  - advection
  - elliptic problems

Possible Further Topics:

- Fast linear solvers, e.g., Krylov, multigrid
- Spectral methods, Fourier and Chebyshev
- Finite-element methods
- Least-squares methods
- Monte-carlo methods

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 courses

as a prerequisite. Basic numerical methods, e.g. interpolation, numerical integration, numerical differentiation, numerical linear algebra and root finding, are introduced and then applied to the solution of ordinary and partial differential equations. This approach helps to contextualize the numerical methods and enables us to focus on applications of the methods to practical problems.

Learning Materials

Written notes, recorded lectures, references to textbooks, examples codes in Julia, Jupyter notebooks.

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`.

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 and an oral exam. Although it may not be a form of assessment you are used to, you may find it much more interactive and lightweight than a written final.

MATH 405:
- 60% written assignments
- 15% presentations to group
- 25% oral exam (final)

MATH 607:
- 40% written assignments
- 10% presentations to group
- 25% project
- 25% oral exam (incl project presentation)

Notes:
- There will likely be 7 assignments (subject to change).
- For MATH 405 the oral exam will be on the submitted work and will test the level of understanding of the material by the student. It will be graded as follows:
  - 10: demonstrating basic knowledge
  - 15: good command of basic material (e.g. requiring minimal prompting to explain main ideas)
  - 20: excellent command of basic material and good command of advanced material
  - 25: excellent command of basic and advanced material
- Group projects will be assigned during the lectures
- 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 `https://senate.ubc.ca/policies-resources-support-student-success`UBC Senate website.

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