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 Analysis of Differential Equations	MATH 521	3

PREREQUISITES

I will assume that students have basic background in numerical analysis and scientific computing, e.g., MATH 405, MATH 406 or similar, and basic background in modeling with and/or analysis of PDE, e.g., MATH 400 or similar. Familiarity with function spaces is helpful but will not be assumed. Students should be familiar with at least one of Matlab, Python or Julia

COREQUISITES

CONTACTS

Course Instructor(s)	Contact Details	Office Location	Office Hours
Christoph Ortner	Canvas ortner@math.ubc.ca only for personal enquiries	LSK303	tba

OTHER INSTRUCTIONAL STAFF

tba

COURSE STRUCTURE

The course is primarily concerned with the numerical analysis of finite element methods and spectral methods, developed in traditional lectures (in-person). This year I plan to teach the two subjects side-by-side to highlight the similarities and contrasts.

Active student involvement is highly encouraged; the course content is flexible and when appropriate we can change direction or go on tangents. The course is split approximately into 2/3 numerical analysis theory and 1/3 algorithms and practical computational aspects. Students will work on an independent research project, submit a report and give a presentation of their results.

The course is suitable for applied mathematics students who wish to deepen their training in numerical analysis and scientific computing techniques, and for science/applied science students who plan to use numerical methods in their research but require an introduction to their theory to be able to select the correct methods, and to be able to read relevant papers in the field.

SCHEDULE OF TOPICS

There is a core content (sections [0, 1]) that I plan to cover (about 50-66% of the course) but beyond this the precise content of the course is flexible and will adapt to progress in class, and to the level of student engagement. A tentative and preliminary outline of topics is the following ([3, 4] may be interlaced (to be confirmed)) :

[1] Introduction to key ideas in 1D:
- review finite differences
- P1 finite elements for BVPs
- fourier spectral method for BVPs
- polynomial approximation theory in 1D

[2] Elements of Elliptic PDE Theory
- Sobolev (Hilbert) spaces
- weak form
- well-posedness in H1
- regularity

[3] Finite elements for Elliptic BVPs: this is the backbone of finite element theory and practice; we will cover:
- Galerkin projection, a priori error analysis
- conforming finite element methods, P1, higher order
- Implementation, quadrature, testing of implementation, validation of theory
- analysis of variational crimes

[4] Spectral Methods for Elliptic BVPs
- Fourier spectral methods in dimension > 1
- approximation theory
- Galerkin and Collocation methods, a priori error analysis
- Fast transforms
- implementation, testing of implementation, validation of theory

[5] Other PDE
- details to be confirmed, but may include parabolic, transport, eigenvalue problems, with some focus on qualitative behaviour

[6] Student Presentations & Projects
(see below)

LEARNING OUTCOMES

- Given a PDE problem, select and implement a suitable numerical method
- Understand the fundamental numerical analysis concepts of consistency, stability and convergence in the context of numerical methods for PDEs, both in the context of theory and in practical computations.
- Be able to derive *a priori* (and *a posteriori*) error estimates for model problems.
- Apply the techniques acquired in class to a previously unseen scientific problem.
- Communicate results in both written and oral forms of communication.
- Be able to critically assess and correct one's own work.

LEARNING MATERIALS

Will be posted on Canvas and/or github.

ASSESSMENTS OF LEARNING

- 40% assignments
- 20% in-class presentation
- 40% project (5% proposal, 20% report, 15% viva)

Assignments: I will give plenty of time to complete assignments, hence late assignments or projects will not be accepted. I am tentatively planning for six assignments, out of which the worst grade can be dropped.

Presentation: Each student will give one short presentation on a topic that extends the course material. Details to be discussed with instructor; possible topics include a posteriori error analysis, adaptivity, DGFEM, adjoints, non-confirming or mixed methods, stokes equation, linear elasticity, fast iterative solvers, inverse problems, reduced basis methods, multi-scale methods, and many others.

Project: Separately from the presentation, students will write a project report on a separate topic (that may be related to their research), give a brief presentation outside of class and answer questions on the report and related material from the course

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.**