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, developed in traditional lectures (in-person). Active student involvement is highly encouraged; where appropriate we can change direction of the discussion or go on tangents. Much of the course is focused on theory, but we will also dive into algorithmic and practical computational aspects, in the form of Jupyter notebooks. Finally, students will work on an independent research project, submit a report and give a presentation of their results.

The course should be suitable for applied mathematics students who wish to deepen their training in numerical analysis techniques, and for science/applied science students who plan to use FEM primarily as a tool in their research but require an introduction to the theory of FEM 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:

[0] Introduction to key ideas in 1D

[1] Finite elements for Elliptic BVPs: this section is the *core content* of the course. It is the backbone of finite element theory and practice, and will be tought and examined rigorously. We will cover
- elliptic PDE, weak form, well-posedness in H1, regularity
- Galerkin projection, a priori error analysis
- conforming finite element methods, P1, higher order
- Quadrature, variational crimes
- Implementation, testing of implementation, validation of theory

All subsequent topics are flexible, can be replaced, extended or shortened, and should be only taken as tentative. It will be impossible to cover all topics mentioned below.

[2] Further Topics
- A posteriori error analysis and adaptivity: residual based a posteriori error analysis, adaptive mesh refinement, convergence of a greedy adaptive algorithm, a posteriori error analysis for quantities of interest via adjoints
- Non-conforming and mixed finite element methods: variational crimes in function space, saddle point problems, mixed formulation of elliptic PDE, discretisation of the stokes equation, locking in linear elasticity
- fast solvers
- Inverse problems
- Parametric PDE, reduced basis methods
- multi-scale methods
- …

LEARNING OUTCOMES

- Given a PDE problem, select and implement a suitable finite element 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 possibly github.

ASSESSMENTS OF LEARNING

- 10% in-class midterm on the core content [0, 1].
- 50% self-graded assignments: 40% assignment and 10% grading.
- 40% project (5% proposal, 10% presentation, 25% report)

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 will be dropped. If the mid-term is missed and FOS grants a concession, it will be replaced by an oral exam.

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**.