

We recognize and acknowledge that McMaster University meets and learns on the traditional territories of the Mississauga and Haudenosaunee nations, and within the lands protected by the "[Dish With One Spoon](#)" wampum, an agreement amongst all allied Nations to peaceably share and care for the resources around the Great Lakes.

MATH 723/5GT3 – Functional Analysis 2021 Winter Term

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Website: <https://ms.mcmaster.ca/courses/20132014/term2/math4at3/>

Course Description

This will be an introductory graduate course in Functional Analysis. Functional Analysis is analysis in infinite dimensional vector spaces, such as the space of continuous functions studied in undergraduate analysis, or the spaces of Lebesgue integrable functions L^p . Infinite dimensions can often play havoc with our finite dimensional intuition, leading to some deep and interesting questions in analysis and topology. In this class we will introduce the fundamental theory of Banach and Hilbert spaces and the linear transformations on each. Much emphasis will be placed on the great utility of Functional Analysis as a framework for studying many diverse problems in mathematics, as it plays a fundamental role in Fourier analysis, partial differential equations, the calculus of variations, nonlinear and geometrical analysis, index theory, numerical methods, and measure theory.

I hope to cover some of the following topics, mixing the "soft" abstract theory with some more concrete examples of how Functional Analytic methods can be used in mathematics:

- Introduction to linear spaces, normed linear spaces, Banach spaces;
- Sobolev spaces, Hilbert spaces, the Riesz and Lax-Milgram Theorems;
- Uniform bounded theorem, Bounded operators, Closed Graph Theorem;
- Hahn-Banach Theorem and applications;
- Dual spaces, weak and weak-* convergence, reflexive spaces;
- Compact operators, introduction to spectral theory;

- Hille-Yosida Theorem, semigroups;

Throughout, there will be connections to the L^p spaces, Sobolev Spaces, PDE, harmonic analysis, etc.

References:

The lectures will be related to the following two texts:

Peter D. Lax, "Functional Analysis." Wiley-Interscience, 2002.

This can be seen as the main reference. It contains many more topics than I could cover in a whole year!

Haim Brezis, "Functional Analysis, Sobolev Spaces, and PDE". Springer, 2010.

This is also an excellent reference, both for the course and for working mathematicians, especially in the areas of Sobolev spaces, the calculus of variations, elliptic PDE and regularity theory.

Evaluation:

I will be using Kritik for assignments (roughly once a week,) and towards the end of the course each student will choose a topic of their choice and make a short (20 minutes) (Teams) presentation, which will be accompanied by a brief report (up to five pages.)

Prerequisite(s): The prerequisites are Real Analysis (Math 721) and some familiarity with complex analytic functions (an undergraduate level course is sufficient.)

Class Activities

*Synchronous lectures will take place on Teams from **1:00pm – 2:30pm on Mondays and Thursdays.***

Recorded lectures will be made available on Teams.

Virtual Course Delivery

To follow and participate in virtual classes it is expected that you have reliable access to the following:

- A computer that meets performance requirements [found here](#).
- An internet connection that is fast enough to stream video.



- Computer accessories that enable class participation, such as a microphone, speakers and webcam when needed.

If you think that you will not be able to meet these requirements, please contact uts@mcmaster.ca as soon as you can. Please visit the [Technology Resources for Students page](#) for detailed requirements. If you use assistive technology or believe that our platforms might be a barrier to participating, please contact [Student Accessibility Services](#), sas@mcmaster.ca, for support.

The final grades will be computed as follows.

Grade Component	Weight
Kritik assignments	75%
final presentation + report	25%

Requests for Relief for Missed Academic Term Work

[McMaster Student Absence Form \(MSAF\)](#): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar “Requests for Relief for Missed Academic Term Work”.

Academic Accommodation of Students with Disabilities

Students with disabilities who require academic accommodation must contact [Student Accessibility Services \(SAS\)](#) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University’s [Academic Accommodation of Students with Disabilities](#) policy.

Academic Accommodation for Religious, Indigenous Or Spiritual Observances (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the [RISO](#) policy. Students should submit their request to their Faculty Office **normally within 10 working days** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

Courses with An On-Line Element

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

Online Proctoring

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

Academic Integrity

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

It is your responsibility to understand what constitutes academic dishonesty.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: “Grade of F assigned for academic dishonesty”), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the [Academic Integrity Policy](https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/), located at <https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/>

The following illustrates only three forms of academic dishonesty:

- plagiarism, e.g. the submission of work that is not one’s own or for which other credit has been obtained.
- improper collaboration in group work.
- copying or using unauthorized aids in tests and examinations.

Authenticity / Plagiarism Detection

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic integrity have been upheld** (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to the [McMaster Office of Academic Integrity's](#) webpage.

Conduct Expectations

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all our living, learning and working communities. These expectations are described in the [Code of Student Rights & Responsibilities \(the "Code"\)](#). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

Copyright and Recording

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors.

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

Extreme Circumstances

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.