

# MATH 4154A/9054A - Course Outline - FW 2023-24

## 1. Course Information

### Course Information

Mathematics 4154A-001 – Functional Analysis, September-December 2023.

Mathematics 9054A-001 – Functional Analysis, September-December 2023.

In-person lectures Tu 12:30-2:30, Th 12:30-1:30; MC17

### List of Prerequisites

Math 4154A Prerequisite(s): Mathematics 2120A/B, Mathematics 3122A/B. Pre-or Corequisite(s): Mathematics 3124A/B.

Math 9054A Prerequisite(s): Linear Algebra, Metric Spaces, Basic Complex Analysis.

Unless you have either the requisites for this course or written special permission from your Dean's Designate (Department/Program Counsellors and Science Academic Counselling) to enroll in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

## 2. Instructor Information

Gord Sinnamon, Professor, Department of Mathematics. Email – [sinnamon@uwo.ca](mailto:sinnamon@uwo.ca). Office – Middlesex College Room 103e. Extension – 86535.

Drop-in office hours will be held in-person in MC 103e at times to be determined in consultation with the class. To meet outside these times, email me for an appointment and include a *definite day and time* that you would like to meet.

## 3. Course Syllabus, Schedule, and Delivery Mode

### Course Content

Description: Hilbert spaces:  $L^2$  spaces, orthogonal complements, dual spaces, Riesz representation theorem, the Fredholm alternative, spectral resolution of compact normal operators. Banach spaces: Hahn-Banach theorem, bounded linear operators, adjoints, closed graph and Banach Steinhaus theorems.

### Course Learning Outcomes

1. Prove that a given functional is or is not a norm.
2. Define the orthogonal complement of a subset of a Hilbert space.
3. Given Banach spaces  $X$  and  $Y$ , prove that the collection of all bounded, linear operators from  $X$  to  $Y$  is a Banach space.
4. State the Hahn-Banach theorem for normed spaces.

5. Prove that the spectrum of a bounded, linear operator on Hilbert space is a closed, bounded subset of  $\mathbb{C}$ .
6. Define the notion of a compact operator between two normed spaces.

### **Key Sessional Dates**

Classes begin:	September 7, 2023
Last day to add:	September 15, 2023
No classes:	September 29, 2023
Holiday:	October 9, 2023
Reading Week:	October 30 to November 5, 2023
Last day to drop:	November 13, 2023
Classes end:	December 8, 2023
Exam period:	December 10 to 22, 2023

Although the intent is for this course to be delivered in person, should any university-declared emergency require some or all of the course to be delivered online, either synchronously or asynchronously, the course will adapt accordingly. The grading scheme will not change. Any assessments affected will be conducted online as determined by the course instructor.

### **Course Materials**

*Required* Textbook: Linear Functional Analysis, Second Edition, by Rynne and Youngson, Springer-Verlag, London, 2008. This is a free download from Western Library.

Occasional additional course material will be provided online via OWL.

*Optional* Textbook: Elementary Functional Analysis, by MacCluer, Springer Science+Business Media, LLC, 2009. This is a free download from Western Library.

### **Learning Management System (OWL)**

If students need assistance with the course OWL site, they can seek support on the OWL Help page. Alternatively, they can contact the Western Technology Services Helpdesk. They can be contacted by phone at 519-661-3800 or ext. 83800.

### **Technical Requirements**

## **4. Methods of Evaluation**

### **Course Grade**

The final course grade will be determined by student performance on

*Seven Written Assignments [21%]:* Due at the beginning of class on September 21, September 28, October 5, October 19, November 9, November 23 and November 30. Assignments will be equally weighted.

Assignments in Math 9054A will be more demanding than assignments in Math 4154A.

If you need a one-week extension for an assignment contact your instructor *before the due date*. This is not an academic accommodation.

*Two In-Class Tests [40%]:* (110 minutes) October 10 and November 14 in class. Tests will be equally weighted. Tests in Math 9054A will be more demanding than tests in Math 4154A.

*Final Exam [39%]* (Three hours) To be scheduled in consultation with the class. The final exam will cover the entire course. The exam in Math 9054A will be more demanding than the exam in Math 4154A.

### **Make-up Dates**

There will be no make-up for Assignments or Tests. Special Examinations (make-ups for the final) will be scheduled in January.

## **5. Student Absences**

If you need a one-week extension for an assignment contact your instructor *before the due date*. This is not an academic accommodation.

If you are unable to meet a course requirement due to illness or other serious circumstances, please follow the procedures below.

### **Assessments Worth Less Than 10% of Course Grade**

Contact your instructor first.

If academic accommodation for up to three missed assignments is granted by the course instructor (or a faculty counsellor,) then your mark for those assignments will be replaced by the average mark on your other assignments. There will be no makeups for missed assignments. If more than three are missed, see the next section.

### **Assessments Worth At Least 10% of Course Grade**

Graduate Students: Contact your instructor.

Undergraduate Students: (Also contact your instructor.) For work totalling 10% or more of the final course grade, you must provide valid medical or supporting documentation to the Academic Counselling Office of your Faculty of Registration as soon as possible. For further information, please consult the [University's medical illness policy \(click here\)](#) and review the [Student Medical Certificate \(click here\)](#). In the event that the links do not work, type either

- [https://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/academic\\_consideration.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/academic_consideration.pdf) (for policy)
- [https://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/medicalform.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf) (for certificate)

into your browser.

If academic accommodation for more than three missed assignments is granted by a faculty counsellor, then each other assignment will count for 7% and the excess assignment mark will be assigned to the final exam. There will be no makeups for missed assignments.

If academic accommodation for one test is granted by a faculty counsellor, then the other test will count for 30% and the excess test mark will be assigned to the final exam. If academic accommodation for both tests is granted by a faculty counsellor, then the entire test mark will be assigned to the final exam. There will be no makeups for missed tests.

### **Absences From Final Examinations**

If you miss the Final Exam, please contact the Academic Counselling office of your Faculty of Registration as soon as you are able to do so. They will assess your eligibility to write the Special Examination (the name given by the University to a makeup Final Exam).

You may also be eligible to write the Special Exam if you are in a “Multiple Exam Situation” (e.g., 3 or more exams in 23-hour period, 4 or more exams in a 47-hour period).

If a student fails to write a scheduled Special Examination, the date of the next Special Examination (if granted) normally will be the scheduled date for the final exam the next time this course is offered. The maximum course load for that term will be reduced by the credit of the course(s) for which the final examination has been deferred. See the Academic Calendar for details (under Special Examinations).

### **Accommodation and Accessibility**

#### **Religious Accommodation**

When a course requirement conflicts with a religious holiday that requires an absence from the University or prohibits certain activities, students should request accommodation for their absence in writing at least two weeks prior to the holiday to the course instructor and/or the Academic Counselling office of their Faculty of Registration. Please consult [the University’s list of recognized religious holidays \(click here\)](#), which is updated annually. Alternatively, you may wish to enter

- <https://multiculturalcalendar.com/ecal/index.php?s=c-univwo>

directly into your browser.

#### **Accommodation Policies**

Students with disabilities are encouraged to contact Accessible Education, which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. Students can consult [the policy on Academic Accommodation for Students with Disabilities \(click here\)](#). Alternatively, type

- [www.uwo.ca/univsec/pdf/academic\\_policies/appeals/Academic Accommodation\\_disabilities.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic_Accommodation_disabilities.pdf)

into a browser.

## 6. Academic Policies

The website for Registrarial Services is <http://www.registrar.uwo.ca> (click here).

In accordance with [policy \(click here\)](#), the centrally administered e-mail account provided to students will be considered the individual's official university e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the University at their official university address is attended to in a timely manner. The policy referenced above can also be accessed by typing

- [https://www.uwo.ca/univsec/pdf/policies\\_procedures/section1/mapp113.pdf](https://www.uwo.ca/univsec/pdf/policies_procedures/section1/mapp113.pdf)

into your browser.

Scholastic offences are taken seriously and students are directed to read the appropriate [policy \(click here\)](#), specifically, the definition of what constitutes a Scholastic Offence. This policy can also be accessed by typing

- [http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/scholastic\\_discipline\\_undergrad.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf)

into your browser.

In the event of a health lock-down, tests and examinations in this course will be conducted using a remote proctoring service. By taking this course, you are consenting to the use of this software and acknowledge that you will be required to provide personal information (including some biometric data) and the session will be recorded. Completion of this course will require you to have a reliable internet connection and a device that meets the technical requirements for this service. More information about this remote proctoring service, including technical requirements, is available on Western's Remote Proctoring website at <https://remoteproctoring.uwo.ca> (click here).

## 7. Support Services

Please visit the Science & Basic Medical Sciences Academic Counselling webpage for information on adding/dropping courses, academic considerations for absences, appeals, exam conflicts, and many other academic related matters: <https://www.uwo.ca/sci/counselling/> (click here).

Students who are in emotional/mental distress should refer to Mental Health@Western by visiting their website <https://uwo.ca/health/> (click here) for a complete list of options about how to obtain help.

Western is committed to reducing incidents of gender-based and sexual violence and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced sexual or gender-based violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts [is available \(click here\)](#). If you cannot access the link you can type

- [https://www.uwo.ca/health/student\\_support/survivor\\_support/get-help.html](https://www.uwo.ca/health/student_support/survivor_support/get-help.html)

into your browser. To connect with a case manager or set up an appointment, please email [support@uwo.ca](mailto:support@uwo.ca).

Please contact the course instructor if you require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact [Accessible](#)

[Education \(click here\)](#) if you have any questions regarding accommodations. If the link provided does not work, type

- [http://academicsupport.uwo.ca/accessible\\_education/index.html](http://academicsupport.uwo.ca/accessible_education/index.html)

into your browser.

Learning-skills counsellors at the [Student Development Centre \(click here\)](#) are ready to help you improve your learning skills (alternatively, type <https://learning.uwo.ca> into your browser). They offer presentations on strategies for improving time management, multiple-choice exam preparation/writing, textbook reading, and more. Individual support is offered throughout the Fall/Winter terms in the drop-in Learning Help Centre, and year-round through individual counselling.

Additional student-run support services are offered by the USC, <https://westernusc.ca/services/> ([click here](#)).