MAT 223 Linear Algebra
Fall 2016

Contents

We realize this syllabus is very long, but it contains lots of important information, including most of the types of questions you're likely to have throughout the semester. Not reading it, and asking the instructor a question easily located here, is bad etiquette. The above table of contents is "clickable" for easy navigation.

1 Course Website

All important information is regularly maintained on the course website

<center>http://www.math.toronto.edu/nhoell/MAT223</center>

Please bookmark the page for your convenience and check in regularly. You are expected to check your email regularly throughout the semester as you will receive exam and other course-related announcements sent to your inbox throughout the semester. Important announcements will be posted on the course website as well.

2 Content of this Course

This course is an introduction to linear algebra. Many of you have no doubt already seen some ways of solving systems of linear equations in high school. In this course we greatly expand on what you may have seen and consider how to deal with such systems in a systematic and general way. Dealing with systems of linear equations in an abstract manner is profoundly useful for developing general methods for solving such systems. These methods have tremendous applications across a variety of disciplines including *physics, economics, chemistry, statistics, mathematics, operations research, artificial intelligence, computer science, imaging, neuroscience, machine learning,* and other areas of science. At times the material may feel quite abstract and removed from direct applications but we will try to stay as grounded as possible and highlight the importance and utility of all the general techniques we present. Mastery of this material is the first step on the long journey towards a proper scientific training, as it is in many ways the de facto *lingua franca* in the sciences.

Technical Details

Make sure you are aware of the following University details regarding this course.

- Prerequisites: High School Level Calculus

- Exclusion: MAT240H1

- Distribution Requirement Status: This is a Science course

- Breadth Requirement: The Physical and Mathematical Universes (5)

3 Lecture Sections

There are six instructors for the course as listed below.

- LEC0101: T 10:00–12:00 in MP203 & W 14:00–15:00 in MP102
  Instructor: Professor Soheil Homayouni-Boroojeni
  Email: homayoun@math.utoronto.ca

- LEC0102: T 10:00-12:00 in BA1130 & W 1:00-2:00 in SS2102
  Instructor: Professor Sean Uppal
  Email: uppal@math.utoronto.ca

- LEC0201: T 13:00–15:00 & W 16:00–17:00 in MP202
  Instructor: Professor Kin Kwan Leung
  Email: `kk.leung@utoronto.ca`

- LEC0301: T 13:00–15:00 & R 13:00–14:00 in MP103
  Instructor & Coordinator: Professor Nicholas Hoell
  Email: `nicholashoell@gmail.com`

- LEC0401: TWR 15:00–16:00 in MP202
  Instructor & Coordinator: Professor Hoell
  Email: `nicholashoell@gmail.com`

- LEC0501: W 13:00–15:00 in SS2135 & R 14:00–15:00 in SS2135
  Instructor: Professor Konstantin Matetski
  Email: `matetski@math.utoronto.ca`

- LEC5101: T 18:00–21:00 in BA1160
  Instructor: Professor Anup Dixit
  Email: `anup.dixit@mail.utoronto.ca`

- LEC5201: T 19:00–20:00 & R 18:00–20:00 in SS2135
  Instructor: Professor Karol Koziol
  Email: `karol@math.utoronto.ca`

Each of the above instructors has weekly office hours at times and locations listed on the course website.

Lecture Behaviour

None of the instructors take attendance, although we all **strongly encourage attendance** as it is the best way to stay on top of material throughout the term as well as to get viewpoints and idiosyncrasies particular to the instructors (who, after all, are writing the exams you'll be taking!) Here are some additional thoughtlets on attending lecture.

1. Don't feel shy about raising your hand and asking for clarification on points of confusion. Whatever your confusion, there are no doubt others in the room who share it. Moreover, **the instructors of MAT223 welcome and encourage your active participation**. It helps *us* learn about what students may be struggling with.

2. There is a big difference between being merely *physically present* and being *intellectually present*. Being physically present is no harder than finding a seat. Being intellectually present requires paying attention. In particular texting, being on your laptop, having earbuds in, chatting, or generally showing obvious signs of disengagement not only hinders your ability to learn but they are things your instructors will point out and ask you to stop doing.

3. If you miss a lecture due to illness or other understandable reasons, feel free to ask your instructor after the next lecture you attend about topics you may have missed. In addition you will find it helpful to make friends over the term with whom you can share notes. Simply sending an email to your instructor along the lines of "I was sick yesterday what did you cover?" however will, for what I hope are obvious reasons, go unanswered.

4 Tutorials

There are tutorial sections for this course and you must be registered to one. They are offered on TWR at various times for your convenience. These are your opportunity to learn directly from your TA and ask questions you may have lingering from the main lecture hours. Tutorials begin on the third week of classes, namely on Tuesday, September 27th. As well, there will be quizzes in tutorials throughout the semester and therefore you **must bring paper and a pen/pencil** to tutorials in order to write the quizzes. As well, you may **only write quizzes in the tutorial section you are registered in**. If you have not managed to register for tutorial, either because all tutorials were full, or because the deadline has passed, you must see the course coordinator.

5 Textbook

5.1 Required Text

Our required text will be *Linear Algebra with Applications* by Keith Nicholson, 7th edition ISBN-13: 978-1-25-945514-8. We are only using selected portions from the text. The bookstore has copies of this book for us listed as **Custom Publication for University of Toronto** (note: Sean Uppal is NOT the author, the author is Nicholson, some printings of this book have the wrong name on the cover). It is a nice, slim softcover version containing only the parts we'll be using for this course. If **you decide to use an older edition** of the book, that's fine but you **do so at your own risk** because the suggested problems may not match those which are in the seventh edition. It is **the students' responsibility alone** to make sure you are working through analogous problems if in fact you decide to use an older edition.

5.2 Optional Texts

You may also wish to consult the text *Linear Algebra,* by Friedberg, Insel & Spence, 4th ed. ISBN: 978-0-130-08451-4. This book is often used for the specialist linear algebra course MAT240/MAT247. It's a well written text, with great problems. It happens to be a bit too advanced for this course but for those of you looking to delve deeper, this is a great text to read.

Another excellent book is *Introduction to Linear Algebra* by Strang, 4th ed. ISBN-13: 978-0-980-23277-6. It's an exceptional text, which suffers only from being a bit too advanced (and too comprehensive) for what we'd like to get through this semester. If you find yourself enjoying this course it may be worthwhile to grab a copy of this text as it will serve you well.

Other Materials

In addition to the textbook, we will occasionally post additional problems and references on the course website as the semester progresses. Please don't limit yourself solely to the main text!

6 Homework

No homeworks will be collected for this course. A list of suggested problems, however, is given on the course webpage as well as later in this syllabus. There will occasionally be more **optional problems** posted on the course website.

7 Quizzes

Quizzes will be given in tutorials. These are short problems designed to keep you current on the topics and make sure you don't fall too far behind. Since the lowest two quiz scores are not counted as part of the score in the class **no medical notes are necessary/accepted** in the case of a missed quiz. **You are expected to bring your student identification (T-card), paper and a pen/pencil to tutorials** as the quizzes will be written on paper you bring. You may **only write quizzes in the tutorial section you are registered in**.

8 Grading

Grades will be based according to some quizzes throughout the term, one midterm exam and a final exam. Your final grade in the course will be determined by the following

- *Quizzes: 5%; the lowest two scores will be dropped*
- *Midterms: 25% for the highest, 20% for the lowest*
- *Final Exam: 50%*

The quizzes are given in tutorials throughout the term and are there as a chance for you to get feedback on your progress and understanding thus far. **You are expected to bring your student identification (T-card), paper and a pen/pencil to tutorials** as the quizzes will be written on paper you bring. You may **only write quizzes in the tutorial section you are registered in**.

Note on Exams
No electronic devices/aids will be allowed during the exams. It is the students' responsibility to ensure that the allotted exam time is available.

9 Tests

There are two midterms during the semester. They are held on

1. Midterm 1: Friday, October 14th, 4:10-5:00PM
2. Midterm 2: Friday, November 18th, 4:10-5:00PM

Arrangements may be made for students who have a regularly scheduled University of Toronto class scheduled at that time. If you are such a student you must discuss this issue **with the instructor of the lecture section you are enrolled in** as soon as reasonably possible.

9.1 Missed Tests

There are no makeup tests. A student presenting proof of a **valid** reason for missing a test (see the section on Missed Term Tests in the Rules and Regulations section of the Faculty of Arts and Science 2016-2017 Calendar as well as the following section of this syllabus) will have their grading scheme adjusted to the following

- *Quizzes: 5%; the lowest score will be dropped*

- *Midterm: 35% for the midterm taken*

- *Final Exam: 60%*

In the unlikely event that there are two VALID medical excuses, this procedure will not be followed. Students in this circumstance will have their mark depend 95% on the final exam and 5% on the homeowrk. Almost **every student who has purported to be in this situation has failed the course** due to a very low mark on the final exam. It is strongly advised that you write all 2 term tests. Missing both tests and only taking the final exam is a near guarantee of failing the course.

9.2 Medical Notes

In the case of a legitimate medical issue **medical notes will be accepted ONLY from MDs with a valid CPSO number**. You must present your section Instructor with a University of Toronto Verification of Student Illness or Injury form available at http://www.illnessverification.utoronto.ca/getattachment/index/Verification-of-Illness-or-Injury-form-Jan-22-2013.pdf.aspx .
Some important remarks about these notes.

- These forms **must be submitted to your course instructor within 3 days of the missed test** for the absence to not be penalized. Failure to submit proper, valid and timely documentation will result in a grade of 0 on your missed test.

- The form must have all required fields filled properly and legibly.

- The form must give the doctor's OHIP number.

- The form must be original.

- The form is only considered valid if **completed by a qualifed medical doctor - not an acupuncturist, chiropractor, naturopath or other health care professional**.

- Upon submission of the documentation review of the medical note will be done before it is accepted as valid. The review **may include following up with your doctor, your college registrar, other departmental advisors**.

Presenting a false medical excuse is a severe offence and will be dealt with through the Office of the Dean of the Faculty of Arts and Science.

10   Contact and Math Aid Centre

It is University policy that **instructors need only reply to emails sent from University email accounts**. Acceptable emails are of the form student@utoronto.ca, topstudent@math.toronto.edu, etc. We will not likely ever reply to a non-University email address (those from addresses like, say, studentwhoseemaildidntgetreturned@hotmail.com or studentwhodidntreadthesyllabus@gmail.com). Any email should have the words "MAT223" somewhere in the subject line.

As for email etiquette, sending technical mathematics questions to your instructor is fine if they are **very short** and worded very precisely. Save longer questions for the beginning Q&A part of the following lecture, or ask during office hours, or during your tutorials, or at the Math Aid Centre. We also wish for you to use the online Piazza forum for discussing questions with each other (which we monitor).

10.1   Whom do I contact?

1. For any math-related questions ask any instructor (see above), ask on the Piazza forum, or ask your TA in tutorials, or ask in the MathAid Centre (see below)

2. For enrollment or tutorial changes after September 25th, contact Nicholas Hoell

3. If you have a regularly scheduled University of Toronto course which conflicts with a test date, contact the instructor of the lecture section you are enrolled in.

4. For questions about which math course is right for you, contact the Undergraduate Administrator Donna Birch at `dbirch@math.utoronto.ca`, or in BA6291 or via 416-978-5082.

5. If you require accommodations for a disability, or have any accessibility concerns about the course, the classroom, or course materials, please contact Accessibility Services: `http://www.accessibility.utoronto.ca/index.htm`

6. If you have a personal situation and are concerned about how it may affect your academic performance, please contact your college registrar.

There are TAs for MAT223 regularly assigned to the MathAid center which will be open for help during the academic year at hours to be announced weekly. The MathAid Centre is on the bottom floor of the Physical Geography Building located on 45 St. George St. When you enter the building walk down the stairs and head left. When you reach the end of the hall the MathAid Center is on the left.

Blackboard is used by instructors of MAT223 for sending out email to the class or when entering marks on tests and homeworks. For any important course information and announcements you should look to the course web site listed at the front of this syllabus.

11 Academic Integrity (Important)

Cheating (including plagiarism) is very serious and, consequently, will be taken **very** seriously. Cheating can result in failure **or worse**. Don't do it! I caution you, the instructors of MAT223 are *extremely* diligent in pushing for the maximum possible penalties for those found cheating. Collaboration on the homework problem sets is fine, in fact, we encourage it since discussing problems with your peers helps bolster your problem solving abilities. But any collusion during test situations will be thoroughly punished. This includes talking (or making other extraneous noises of any kind) during a test. We don't tolerate any kind of chatter during tests.

One other thing. There are students for whom the statement "The test is now over, please put your pens and pencils down while we collect the tests" seems to not entirely register. We consider egregious dismissals of our requests to stop writing to be a form of academic integrity violations which we enforce with the same stringency as talking during a test. **It's not worth the risk!**

12 Important Dates

The following are a list of dates you may wish to know and whom to contact in special cases.

1. September 25: Last day to change tutorials. After this date, contact Nicholas Hoell for tutorial changes

2. September 25: Last day to add the course.

3. October 3: Last day to switch from MAT240 to MAT223. If you experience difficulties with this switch contact the college registrar, the instructors are not in control of it.

4. October 14: Midterm #1

5. November 7: Last day to drop without academic consequence.

6. November 18: Midterm 2

13 External Resources

13.1 Accessibility Accommodations

The University of Toronto is committed to accessibility. As such, if you require accommodations for a disability, or have any other accessibility concerns about the course, the classroom or course materials, please contact Accessibility Services, `http://www.studentlife.utoronto.ca/` as soon as possible.

13.2 Writing and English Language Instruction

For information on campus writing centres and writing courses, please visit `http://www.writing.utoronto.ca/`. FREE English language instruction with the ELL Program will

start in Winter 2016. The Communication Cafe offers drop-in discussions, presentations, and debates, along with learning about Canadian culture - no registration necessary. Sessions are facilitated by writing centre instructors. For more information about the English Learning Language (ELL) program, please visit `http://www.artsci.utoronto.ca/current/advising/ell`.

13.3 Other Resources

As well, you may wish to visit any of the following.

- Student Life Programs and Services: `http://www.studentlife.utoronto.ca`

- Academic Success Centre: `http://www.studentlife.utoronto.ca/asc`

- Health and Wellness Centre: `http://www.studentlife.utoronto.ca/hwc`

14 The Menu

We will keep, *very roughly*, to the following schedule (dates refer to week beginning on the Sunday falling on the given MM/DD). The **schedule is not rigid** and may vary depending on which section you are enrolled in. You should consult the course webpage for more accurate information as the course moves on.

- Week of 9/11 ....
    - **Topics:** Overview. Introduction. Systems of linear equations. Gaussian Elimination. Ch 1.
    - **Suggested Problems:** Section 1.1: 1–17, Section 1.2: 1–15

- Week of 9/18 ....
    - **Topics:** Homogeneous equations. Matrices and matrix algebra. Ch 1&2.
    - **Suggested Problems:** Section 1.3: 1–7. 11, & 12. Section 2.1: #1–22.

- Week of 9/25 ....
    - **Tutorials Begin & Quiz 1**
    - **Topics:** Transformations and Multiplication. Ch 2.
    - **Suggested Problems:** Section 2.2: 1–23. Section 2.3: 1–10, 14–24, 27–36.

- Week of 10/2 ....
    - **Quiz 2**
    - **Topics:** Matrix Inverses and Elementary Matrices (but *not* Smith normal form). Ch 2.
    - **Suggested Problems:** Section 2.4: 1–24. Section 2.5: 1–10, 13, & 17–20.

- Week of 10/9 . . . .
    - **Quiz 3**
    - **Midterm** 1 on Friday, October 14
    - **Topics:** Vectors, vectors, vectors! Linear transformations. Ch 2& 4.
    - **Suggested Problems:** Section 2.6: 1–25. Section 4.1: 1–27.

- Week of 10/16 . . . .
    - **Quiz 4**
    - **Topics:** The vector space $\mathbb{R}^n$. Dot products, projections, planes (but *not* the determinant form of the cross product), subspaces. Chs 4&5.
    - **Suggested Problems:** Section 4.2: 1–25, 32–34, 37–39, & 41–45. Section 5.1: 1–23.

- Week of 10/23 . . . .
    - **Quiz 5**
    - **Topics:** Independence, dimension, and orthogonality. Ch 5.
    - **Suggested Problems:** Section 5.2: 1–20. Section 5.3: 1–14 & 16–18.

- Week of 10/30 . . . .
    - **Quiz 6**
    - **Topics:** Determinants, diagonalization, rank, cofactors. Ch 3&5.
    - **Suggested Problems:** Section 5.4: 1–15, 18. Section 3.1: 1–26.

- Week of 11/6 . . . .
    - **Quiz 7**
    - **Topics:** More on determinants. Relation to invertibility. Ch 3.
    - **Suggested Problems:** Section 3.1: 1–26. Section 3.2 1-7, 10–14, 16–18, 20.

- Week of 11/13 . . . .
    - **Quiz 8**
    - **Midterm 2** on Friday, November 18
    - **Topics:** More on determinants. Diagonlization and similarity transformations. Eigenvalues and Eigenvectors. Chs 3&5.
    - **Suggested Problems:** Section 3.3: 1–4, 6–27. Section 5.5: 1–13.

- Week of 11/20 . . . .
    - **Quiz 9**
    - **Topics:** More on eigenproblems. Orthogonality and projections. Ch8.
    - **Suggested Problems:** Section 8.1: 1–17

- Week of 11/27 . . . .
    - **Quiz 10**

- **Topics:** More on orthogonality. Least squares approximation.
    - **Suggested Problems:** Section 8.1: 1–17. Section 5.6: 1–6, 12–14.

- Week of 12/4 . . . .
    - **Topics:** Buffer/Review

In the above, Chapter numbers refer to the seventh edition of Nicholson's text.