MATH 2090: Linear Algebra 2
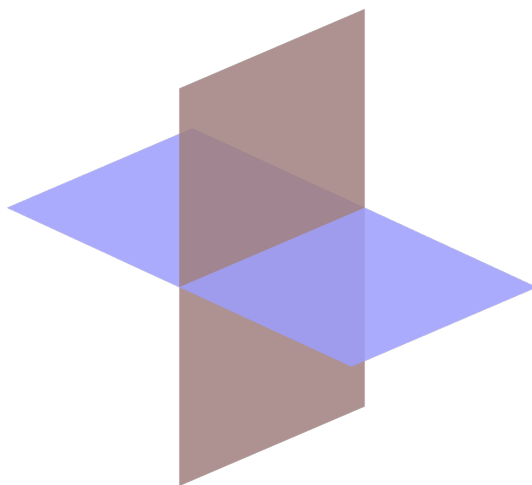# Course Information Sheet and Syllabus
Fall 2018

BASIC COURSE DETAILS

Instructor: Dr. Susan Cooper

Class Times and Location: Tuesdays & Thursdays 10:00 – 11:15 a.m., 208 Armes Lecture Building

Tutorial Times, Location and TAs: *All tutorial sessions are held on Mondays.*

Section	Time	Location	TA
B01	8:30 – 9:20 a.m.	124 Machray Hall	Sooyeong Kim (kims3428@myumanitoba.ca)
B02	3:30 – 4:20 p.m.	301 Biological Sciences	Jeremy Friesen (umfri442@myumanitoba.ca)
B03	3:30 – 4:20 a.m.	124 Machray Hall	Tessa Reimer (reimer46@myumanitoba.ca)

Credit Hours: 3

Pre-Requisites: MATH 1220 (C) or MATH 1300 (B) or MATH 1301 (B).

Note: MATH 2090 is not to be held with MATH 2091 or the former MATH 2300 or the former MATH 2301 or the former MATH 2350 or the former MATH 2352.

INSTRUCTOR CONTACT INFORMATION

Instructor: Dr. Susan Cooper   **Email:** susan.cooper@umanitoba.ca

Office: Machray Hall, Room 464   **Office Phone:** (204) 474–9701

Office Hours: Tuesdays & Thursdays 9:00 – 9:45 a.m.; or by appointment

Correspondences and Appointments: The most reliable way to contact me is via email. I will reply to an email within 24 hours of receiving it Mondays – Thursdays; an email received on a Friday will receive a reply the following Monday. All appointments are to be made via email.

COURSE DESCRIPTION AND GOALS

"Mathematical science is in my opinion an indivisible whole, an organism whose vitality is conditioned upon the connection of its parts." — *David Hilbert*

University of Manitoba Course Calendar Description: (Lab required) The course is intended for students in mathematically rich disciplines. Abstract vector spaces, linear transformations, bases and coordinatization, matrix representations, orthogonalization, diagonalization, principal axis theorem.

General Course Description and Goals: One of the great advantages of studying mathematics is that it helps us develop the ability to handle abstract ideas. Linear algebra allows us to cultivate this ability with concrete examples, mathematical rigor, and beautiful applications. The study of linear algebra involves topics that are important branches of mathematics which are thriving and intriguing in their own right. As such, it is not surprising that linear algebra hosts many applications to subjects such as geometry, computer science, physics, and economics (just to name a few!).

MATH 2090 is a one-term undergraduate course that provides an in-depth study of vector spaces and linear transformations. Roughly speaking, a vector space is a set of objects that is equipped with two operations, namely addition and scalar multiplication, which satisfies a number of rules. The objects, called vectors, can be polynomials, functions, sequences, complex numbers, etc. A linear transformations between two vector spaces is a function between the two spaces which preserves addition and scalar multiplication. Examples of linear transformations include rotations and permutations. We will ask questions such as: what does it mean for two vector spaces to "behave the same"?; what is the analog of length or angle measure in the abstract setting? A deep understanding of linear algebra is fundamental for higher-level pure mathematics as well as for subjects that make use of its vast utility. With numerous applications, the language used for the subject will be abstract so that it can be substituted in many different ways.

By considering concrete examples, you will make conjectures and then try to verify or disprove them. You will gain facility and become confident that you can *do* mathematics and you will experience the joy of discovering hidden patterns and mathematical truths. After successful completion of the course, students will be able to state, prove, apply fundamental theorems, and construct and work with a variety of concrete examples. In addition, students will be well-prepared for higher-level mathematics courses.

COURSE MATERIALS

Textbook: *Linear Algebra*, third edition, by Larry Smith

Note: At times, we will supplement the course with material not presented in the textbook. Thus the lecture notes are the main resource for this course. Most linear algebra textbooks cover much of the same material. However, notation and assumptions may vary from the lecture notes and textbook. Below are two open source textbooks that you might find helpful:

- *Linear Algebra with Applications* by W. Keith Nicholson: available at
    https://lyryx.com/products/mathematics/linear-algebra-applications/
- *Linear Algebra Done Wrong* by Sergei Treil: available at
    https://www.math.brown.edu/~treil/papers/LADW/LADW.html

Course Web-Page: We will use UM Learn and the instructor's web-page which can be found at
    http://server.math.umanitoba.ca/~coopers5/courses_umanitoba/math2090_f18.html

ASSESSMENTS AND COURSE GRADES

Suggested Exercises and Readings: Mathematics is not a spectator sport. The best way to learn mathematics is by doing mathematics! A collection of exercises and readings from the textbook and provided handouts will be assigned regularly. It is highly recommended that you carefully read the material and attempt the suggested exercises. Although your solutions to the suggested exercises will not be collected for credit, you are encouraged and welcome to discuss your solutions with a TA or myself for feedback either in office hours or before/after class meetings. Note that you should attempt the suggested exercises regularly and as the topics are presented – this will help you keep on track and make sure you have solid foundations before moving on to the next topic.

Dictionary Quizzes: The mastery of mathematics requires knowing and understanding many definitions, especially for linear algebra which has numerous and varied applications. You will be given five *Dictionary Quizzes* (see the section "Course Schedule and Important Dates"), each administered in your tutorial meetings. For these quizzes you will be given roughly five minutes to define one or two terms and provide an example and/or non-example of each. Your grade will be comprised of the correctness of the definition(s) and example(s) as well as a completion credit from the *Tutorial Worksheet* (see below) administered during the same tutorial meeting. Note that calculators and reference material (texts, notes, translators, cell phone, etc.) will **not** be allowed on the Dictionary Quizzes. Your lowest Dictionary Quiz score will be dropped from the calculation of your final course grade.

Mastery Quizzes: Five *Mastery Quizzes* will be given based on the suggested exercises and definitions from class. Calculators and reference material (texts, notes, translators, cell phone, etc.) will **not** be allowed on the Mastery Quizzes. These quizzes are intended to gauge your understanding of the material while presenting opportunities for you to practice writing solutions in a timed-setting. Solutions will be graded based on correctness, clarity, and style/creativity. Any necessary special grading rules will be provided beforehand. All feedback is meant to *improve* your mathematical abilities and communication. Your lowest Mastery Quiz score will be dropped from your course grade.

Tutorial Worksheets: The tutorial sessions are designed to deepen your knowledge of the course material. In every tutorial session, you will be asked to work on a *Tutorial Worksheet*. The teaching assistant will be available to answer your questions and help you work through any problems re-emphasizing course content. If a *Dictionary Quiz* is administered during the tutorial meeting, then you will be asked to show and/or submit your work for the completion credit of the *Dictionary Quiz*; you do not have to complete the worksheet or have absolutely correct solutions, but an indication of serious effort is required for this part of the quiz credit. Your attendance and active participation is strongly encouraged!

Examinations: There will be one mid-term examination administered in two parts and one 3-hour cumulative final examination. The schedule is:

Examination	Date	Time and Location
Mid-Term Exam Part I	Monday, October 15	In Assigned Tutorial Session
Mid-Term Exam Part II	Thursday, October 18	10 – 11:15 a.m., 208 Armes (in class)
Final Exam	In December – TBA	TBA (set by U of M Registrar)

Calculators and/or reference material will **not** be allowed on the mid-term and final examinations. Any necessary special grading rules for the examinations will be announced and discussed prior. In general, solutions to problems will be assessed based on correctness, clarity, and style. Feedback on your solutions will be provided on your mid-term examination and is meant to improve your mathematical abilities and communication. Grades and feedback on your mid-term examination solutions will be provided prior to the Voluntary Withdrawal Deadline.

Deferred Quizzes and Examinations: There will be no deferred *Dictionary* or *Mastery Quizzes*. However, your lowest score for each type of quiz will be dropped in the calculation of your final course grade. Deferred mid-term examinations will only be granted for unavoidable, documented circumstances as described below:

Circumstance	Required documentation
Illness or other medical situation	Official note from clinic, hospital, doctor, nurse, or other health care provider
Military service	Official military activation orders
Funeral or other family emergency	Official documentation from newspaper, funeral, or medical official
Sports or other official U of M activity	Official documentation from U of M athletics or activity's faculty adviser

Students who wish to request a deferred mid-term examination must contact the instructor within 48 hours of the scheduled start time (initial email contact is sufficient). Please note that recreational activities do not qualify for deferred examinations. If you have a pre-existing conflict with an assessment, you are expected to make alternative arrangements *beforehand.*

As per university policy, requests for deferred final examinations are made to the student's faculty, school, or academic advising office and must be filed within 48 hours of the date of the missed examination. Full information on this policy can be found at:

http://umanitoba.ca/student/records/finals/682.html

Class/Tutorial Attendance and Participation: This course covers a large amount of material and may seem very fast-paced and abstract. Your understanding of the course material will be greatly supported by regular attendance and engagement in class and tutorial meetings. Although you are expected to attend every class and tutorial meeting and to fully participate in class discussions, attendance will not be taken or be used in the calculation of course grades outside of the credit allocated for the quizzes and examinations. However, you are responsible for any missed material when absent. If time permits, we will discuss some of the suggested exercises. In such discussions, students will be asked to share their ideas. Please take your turn in these activities – it will greatly improve your understanding of the material. In particular, if you are absent from class then you will miss the opportunity to learn from your classmates.

Evaluation Scheme and Letter Grades: Final course grades will be determined by the following scheme:

Task	Percentage of Grade
Dictionary Quizzes	5%
Mastery Quizzes	15%
Mid-Term Examination	30%
Final Examination	50%

Note: A total of 5 Dictionary and 5 Mastery Quizzes will be administered. Your lowest quiz score for each type will be dropped from the calculation of your final course grade.

Below are the minimum cut-off ranges for grades; these may decrease at the instructors' discretion.

Letter Grade	Percentage Out Of 100	Final Grade Point Value
A+	95–100	4.5
A	86–94	4.0
B+	80–85	3.5
B	72–79	3.0
C+	65–71	2.5
C	60–64	2.0
D	50–59	1.0
F	Less than 50	0

COURSE SCHEDULE AND IMPORTANT DATES

The topics schedule below is subject to change at the discretion of the instructor and/or based on learning needs of the students (subject to Section 2.8 of Responsibilities Of Academic Staff With Regard To Students). Assessment dates will not change. *Quizzes will be administered in the tutorials.*

Dates	Topics	Dictionary Quiz	Mastery Quiz
Sept. 5–7	vector spaces		
Sept. 10–14	vector spaces and subspaces	# 1 Sept. 10	
Sept. 17–21	linear independence and dependence, bases, dimension		# 1 Sept. 17
Sept. 24–28	bases, dimension, linear transformations	# 2 Sept. 24	
Oct. 1–5	matrices of linear transformations, change of coordinates		# 2 Oct. 1
No Classes: October 8 (Thanksgiving Day)			
Oct. 8–12	matrices of linear transformations, change of coordinates		
Mid-Term Examination Part I: Monday, October 15 (in tutorial session)			
Mid-Term Examination Part II: Thursday, October 18 (in class)			
Oct. 15–19	systems of linear equations		
Oct. 22–26	eigenvalues, eigenvectors, determinants, characteristic polynomial	# 3 Oct. 22	
Oct. 29–Nov. 2	determinants, characteristic polynomial, diagonalization		# 3 Oct. 29
Nov. 5–9	scalar products, inner product spaces, Gram-Schmidt procedure	# 4 Nov. 5	
No Classes: November 12–16 (Remembrance Day & Fall Term Break)			
Voluntary Withdrawal Deadline: Monday, November 19			
Nov. 19–23	isometries, Riesz Representation Theorem, self-adjoint transformations		# 4 Nov. 19
Nov. 26–30	Spectral Theorem, Principal Axis Theorem	# 5 Nov. 26	
Dec. 3–7	Hermitian, Normal, Unitary matrices		# 5 Dec. 3
Final Examination: Date, Time, Location To Be Determined By U of M Registrar			

UNIVERSITY AND DEPARTMENT OF MATHEMATICS SUPPORT OFFICES AND POLICIES

A list (entitled Schedule "A") of supports available to students, including mathematical support, can be found on the course web-page(s).

FIPPA STATEMENT OF PURPOSE: CROWDMARK

We may use the platform *Crowdmark* in order to assess quizzes and examinations. In such instances, your personal information is being collected under the authority of The University of Manitoba Act. It will be used for the purposes of grading papers and providing feedback to students. Personal information will not be used or disclosed for other purposes, unless permitted by The Freedom of Information and Protection of Privacy Act (FIPPA). The University of Manitoba has taken steps to ensure that its agreement with Crowdmark, Inc. for services provided by the Crowdmark application is in compliance with FIPPA. Please be aware that information held by Crowdmark Inc. may be transmitted to and stored on servers outside of the University of Manitoba, or Canada. The University of Manitoba cannot and does not guarantee protection against the possible disclosure of your data including, without limitation, against possible secret disclosures of data to a foreign authority in accordance with the laws of another jurisdiction. If you have any questions about the collection of personal information, contact the Access and Privacy Office (tel. (204) 474–9462), The University of Manitoba, 233 Elizabeth Dafoe Library, Winnipeg, Manitoba, Canada, R3T 2N2.

EXPECTATIONS

Recording Class Lectures: Susan Cooper and the University of Manitoba hold copyright over the course materials, presentations, and lectures which form part of this course. No audio or video recording of lectures or presentations is allowed in any format (including photographs), openly or surreptitiously, in whole or in part without permission. Course materials (both paper and digital) are for the participant's private study and research.

Using Copyrighted Material: Please respect copyright. We will use copyrighted material in this course. I have ensured that the content I use is appropriately acknowledged and is copied in accordance with copyright laws and University guidelines. Copyrighted works, including those created by me, are made available for private study and research and must not be distributed in any format without permission. Do not upload copyrighted works to a learning management system (such as UM Learn), or any website, unless an exception to the *Copyright Act* applies or written permission has been confirmed. For more information, see the University's Copyright Office web-site at http://umanitoba.ca/copyright/ or contact um_copyright@umanitoba.ca.

Course Technology: It is the University of Manitoba policy that all technology resources are to be used in a responsible, efficient, ethical and legal manner. During class meetings and for course quizzes/examinations/assignments, it is expected that you only use technology for educational purposes and that the only technology used is approved by myself and/or the University of Manitoba Student Accessibility Services. You should not participate in personal direct electronic message/posting activities (such as e-mail, texting, video, social networking, etc.) during scheduled class time – this is not only in your best interests for understanding the course material but is respectful behaviour for your classmates. If you absolutely need to take an expected call, then please use the vibrate mode on your cell phone and leave the classroom before using the phone.

Class Communication: You are required to obtain and use your University of Manitoba email account for all communication between yourself and the university. All communication must comply with the Electronic Communication with Students Policy.

Student Accessibility Services: The University of Manitoba is committed to providing an accessible academic community. *Students Accessibility Services (SAS)* offers academic accommodation supports and services such as note-taking, interpreting, assistive technology and exam accommodations. Students who have, or think they may have, a disability (e.g. mental illness, learning, medical, hearing, injury-related, visual) are invited to contact SAS to arrange a confidential consultation. Students are welcome to meet with the instructors to discuss the accommodations recommended by SAS.

> Student Accessibility Services
> http://umanitoba.ca/student/saa/accessibility/
> 520 University Centre
> Phone: (204) 474–7423
> Email: Student_accessibility@umantioba.ca

Academic Integrity: You are expected to be academically honest. This means, for example, providing a list of the people (if any) with whom you worked and providing a list of sources other than the textbook (if any) that you used to complete an assignment. Although you are encouraged to work together, you should never submit anything that you do not understand or is not written in your own words. The following excerpt about Academic Honesty is taken from the Department of Mathematics web-page:

The Department of Mathematics, the Faculty of Science and the University of Manitoba regard acts of academic dishonesty in quizzes, tests, examinations or assignments as serious offences and may assess a variety of penalties depending on the nature of the offence. Acts of academic dishonesty include bringing unauthorized materials into a test or exam, copying from another student, plagiarism and examination personation. Students are advised to read the sections entitled "Academic Integrity" and "Final Examinations" (in particular, the section "Examination Personations") in the "General Academic Regulations" section of the current Undergraduate Calendar.

Penalties for violation include being assigned a grade of zero on a test or assignment, being assigned a grade of "F" in a course, compulsory withdrawal from a course or program, suspension from a course/program/faculty or even expulsion from the University. For specific details about the nature of penalties that may be assessed upon conviction of an act of academic dishonesty, students are referred to University Policy 1202 (*Student Discipline Bylaw*) and to the Department of Mathematics policy concerning minimum penalties for acts of academic dishonesty. Information regarding cheating and plagiarism is also available from the Faculty of Science web-page.

Students are encouraged to visit the University of Manitoba Academic Integrity site for further information.

Expectations Concerning Pre-Requisites: It is expected that you have mastered the material from the pre-requisite courses. This includes vectors in $\mathbb{R}^n$, matrices, matrix algebra, and systems of linear equations. In general, class time will not be spent reviewing such material. However, any standard linear algebra textbook will present this material should you need any review. You can also find some review in Chapter 10 of the course textbook. Further, you can seek assistance by visiting the Math Help Center (located in 412 Machray Hall).

Classroom Atmosphere: A part of learning is making mistakes. We want to establish a classroom atmosphere where the inevitable false starts and mistakes become an opportunity to improve – not an opportunity for embarrassment. Please be constructive and polite in questioning your colleagues.

Other Expectations and Tips for Success: I ask that you have a well-defined sense of professionalism, that you always put forth your best effort, and that you develop a sense of responsibility to your educational community. I ask that you exhibit a persistent desire to learn. In return I will provide you with significant support. Also:

- Be positive, open, and responsive to feedback.
- Be an active participant - mathematics is learned by doing; this includes participating fully in classroom activities (please, turn your cell phones off during class), completing the suggested exercises, critically thinking about the mathematics during and outside of class. *In order for this class to be successful, it is imperative that you commit to attending class/tutorial sessions regularly, that you commit to preparing beforehand for class/tutorial sessions, and that you commit to participating in class/tutorial sessions!*
- Be/become a "risk taker".
- Be committed.
- Be patient with yourself - it takes time to master newly learned things. Ask for assistance when it is needed. Constantly try to improve yourself as a mathematician.
- Starting with the first class, study in-depth and regularly. This means, for example, that you should do the suggested exercises *before* the next class period.
- It is tempting to just copy available solutions. However, struggling through the exercises on your own is an important phase of the learning process.
- Get help as soon as you need it: ask questions in class and office hours; form a study group with your classmates; consider getting a tutor; use the Math Help Center (located in 412 Machray Hall); use the program LevelUp (see Schedule "A"), etc.
- For examination preparation, practice exercises that have not been assigned.
- Save your solutions to suggested exercises to study from. You may find it helpful to organize your work in a 3-ring binder or notebook for your suggested exercises. You should be able to look at the solutions a month later and understand what is on the paper.
- Mathematics is a language in itself that is common to many sciences across the world. It is crucial that we all use consistent and correct notation. For example, when using the equal sign you should make sure that the quantities on either side of the equal sign are indeed equal.
- Take pride in your work and take your work seriously. This means you should: use complete sentences with proper grammar and correct spelling, write legibly, provide justification for your claims, show all of your work, clearly state all the hypotheses being used, etc.
- Like in all areas of life, constructive feedback can be difficult to digest and accept. Please know that the feedback provided in this course is meant to *improve* your mathematical solutions and communication. Please take the feedback seriously and apply it to your future work.
- Everyone wants you to succeed. Please speak with me regarding any concerns you may have.
- Relax and have fun with the course!