# Linear Algebra

## MATH2270 401

## Course Description

Theory and application of matrices, linear systems, determinants, inverses, vector spaces, linear independence, linear transformations, eigenvalues and eigenvectors, diagonalization, least squares approximation. Includes computer projects.

Pre-Requisite: Within the last year, MATH 1220 w/C grade or better.
Semester: Fall & Spring

**Welcome to Linear Algebra!** This syllabus has a lot of information. Please take time to read through it and re-read relevant parts when questions about the course arise later. This will help you be familiar with the course. Ask your instructor questions you have that are not directly addressed in the syllabus; frequent communication with your instructor is highly recommended. Ignorance regarding information in the syllabus, the course's due dates, assignments, exams, etc., is not accepted nor excused. Be aware and be prepared. Work well and work hard. If you do, then you will learn a lot in this course, and consequently, you will develop mathematically and intellectually, which is part of its many purposes. Have a great semester!

**Description:** This course is an introduction to linear algebra for mathematics, mathematics education, and some science majors, e.g., computer science. It is likely the first serious course that a student will have in theoretical mathematical "structure" (here, algebraic structure). Despite common misconceptions, this course is not a course merely about elementary matrix algebra, though that is definitely part of linear algebra.

This course begins with a development of some of the elementary theory and applications of (real) linear systems, which immediately leads to a study of matrix linear algebra, before moving into more advances topics. Students will learn about elementary row operations, echelon forms, homogeneous systems and proofs of some of their important properties, which we will later apply in more general situations, e.g., the matrix multiplicative associative property and that homogeneous linear systems with more

unknowns that equations have nontrivial solutions. Students will learn about the transpose of a matrix, inverse matrices, and the trace of a matrix, and we will prove several basic and important properties of square matrices, e.g., we will show that the trace of a product is the trace of the commuted product, which is useful in Chapter 6 when investigating invariants of similar matrices.

Students will learn about the multi-linearity, skew-symmetric, and alternating properties of determinants, and their computation via Laplace row/column expansions and their important simplifications using row operations, like say in computing Vandermonde determinants. We will introduce elementary matrices and prove many relevant important properties with them, e.g., the Cauchy Determinant theorem, which says that determinants are multiplicative homomorphisms. We will also prove the very important adjoint formula, and prove, as immediate consequences, a general formula for the inverse of any nonsingular square matrix and then prove the general Cramer's rule as an immediate consequence.

More generally, students will learn about vector spaces, be able to define a vector space, be able to use the concepts of closure, span, linear independence, vector space bases, and finite dimension theory. Students will learn to change bases and use RREFs in row and column spaces to determine bases and vector dependency equations in real finite dimensional linear spaces. Students will learn examples of many common vector spaces, subspaces, and they will learn about many linear spaces from calculus (infinitely many, actually). We will motivate and students will learn about and be able to define the notion of dot product, vector projections, and prove many important relevant properties, e.g., linearity, a generalized law of Cosines the Cauchy-Schwartz inequality, the triangle inequality, and the important dot product formula (inner-product space properties), all in n-dimensional real space. Students will learn about 3-dimensional cross products, prove their linearity, their magnitude formula, and show consequently that determinants compute volumes of parallelepipeds in 3-dimensions.

Students will further learn about the important ideas of additive homomorphisms, monomorphisms, endomorphisms, isomorphisms, automorphisms, and linear transformations. Students will learn many examples of linear transformations, e.g., rotations, logarithms/exponential funtions, derivatives, linear functionals, like definite integrals, and the Fundamental Theorem of finite dimensional real linear spaces, which says that every n-dimensional real vector space is actually isomorphic to **R**^n. This gives

us insight into the general structure of linear spaces and unites ideas from early in the semester to those near the end.

Students will learn about the fundamental spaces of a matrix, and the nullity and rank of a matrix; more generally, we will introduce the perp space of a subspace, and prove a generalization of the rank + nullity theorem. We will show that every linear transformation of a finite dimensional linear space is represented by a matrix multiplication, which depends on specific ordered bases utilized. Hence, once again uniting ideas from the beginning of the semester to those near the end.

We will finish the course with important topics that are needed in Math 2280, Ordinary Differential Equations (ODEs), namely eigenvalues and eigenvectors of linear transformations, in particular, of square matrices, similar matrices, and matrix diagonalization. If time permits, we will cover the isomorphism of polynomial differential operators to $\mathbf{R}[x]$, least squares approximation, and introduce real and complex-inner product spaces, proving many generalized many results mentioned above, e.g., the Cauchy-Schwartz inequality (actually the proofs that I will share in real inner-product spaces immediately generalize to any complex inner-product space). This course will adequately prepare passing students for a subsequent course in Ordinary Differential Equations, e.g., Math 2280, and further courses in beginning abstract algebra, e.g., group theory.

## Course Prerequisites

This course is for students who, within the past year, have successfully completed a second semester Calculus course, such as MATH 1220, with a grade of C or better (preferably, a B or better, and also a third semester Calculus course such as Math 2210).

## Required Text

*Elementary Linear Algebra*: Applications Version, or standard version, 10th Edition, by Howard Anton. (FYI, this text has been on the market for a few years now, so, hard copies should be easy to buy online relatively cheap; furthermore, you may be able to

easily find it in PDF. Also, the 9th edition and 11th editions are different than the 10th, so they are not compatible to use, especially the 9th edition.)

For more information on text accessibility, contact Accessibility & Disability Services at ads@slcc.edu.

## Brief Description of Assignments/Exams

**Homework:** Problems are assigned for each section covered in the text (see the weekly schedule's PDF in Canvas for the list). These written homework problems will be submitted and graded. There four homework sets to submit, in total. Each homework set will be due by the starting time and day of the corresponding relevant exam that covers that homework's material; this includes the last (fourth) homework set, which is due the day of the final exam (again, see the weekly schedule below).

You are expected to work homework exercises from each section that we cover. Further details of how and when to submit homework, and other due dates, etc., will be discussed in class and/or posted in Canvas. Ask your instructor if you have questions! Please keep current on your homework and ask questions about the homework when/if needed. It is very easy to feel overwhelmed if one gets too far behind. Don't allow that to happen! Be and remain diligent.

Of course, regular and often intense practice is essential for learning and retaining mathematics, like learning any demanding subject. You should be prepared to spend at least two hours studying outside of the class for each hour of class. For online classes, that minimum will require additional time to complete the lessons on your own. However, many students find that much more time is required to perform as well as they desire on exams. You are encouraged to work more exercises than those assigned, say, from the text, for extra practice. Do what is necessary for you to perform well.

**Homework Format to Submit:** Students will write, i.e., copy, each homework problem (equation and complete question) on "clean," blank, lined, or graph paper, and write each solution to each assigned problem directly below the written copied problem

itself, in the assigned order from each section. Each page of your homework needs to be clearly marked from what section(s) of the text those problems occur. Problems are expected to be written neatly and legibly, and numerically ordered as in the text with sections ordered chronologically according to the syllabus. It is wise to write your full name on each page of your homework.

Students in my classes are not required to use any online homework software. Furthermore, in my sections, students cannot submit online homework in lieu of written homework.

Present yourself well with well-presented work. For many more difficult problems, several drafts of a problem's solution may need to be crafted before your final draft is ready to be written on your homework's pages that you will submit. Under no circumstances will homework be accepted written on printed-out pages of the text's PDF. Do not turn-in notes from class with the assigned homework problems; I do not need to see your notes. If any of the above homework rules are broken, the instructor may refuse accept/grade the homework. This is a college-level course; you will be expected to submit college-level work.

**How to Submit Homework Sets:** Each homework set must be scanned, converted to a single PDF, and sent to me as a Canvas message's attachment by the start time of the associated exam occurring in-class that day (due dates are listed below). So, by the time you enter our classroom to take a test on a scheduled exam day, you should have already organized your homework (ordered it according to sections, chronologically), scanned all its pages (in the organized order), converted it to a single PDF, and sent it to me in a Canvas message's attachment. Otherwise, it will be late and not accepted. Be aware, that hardcopies of homework will not be accepted for credit. This is in part to prevent the unnecessary passing of germs, viruses, etc. Moreover, submitting homework through Canvas messaging time stamps it and backs it up on servers as examples of a student's work.

Please keep current on your homework and ask questions about the homework when/if finally needed (in-class, online tutoring, STEM Center, etc.). It is very easy to feel overwhelmed if one gets too far behind, which can even be just a few sections. Don't allow that to happen! Be and remain diligent.

**Course Folder:** In case of human or computer error, it is highly recommended that you keep all homework, projects, and exams in a folder (hardcopy or digital) until you have received a final grade for the entire course. Protect yourself!

**Frequent Canvas Grade Checks:** Grades are recorded and computed in Canvas throughout the semester. It is highly recommended that students regularly check their current grades/scores entered in Canvas after each exam is taken and after each assignment is submitted. If a claimed discrepancy is spotted, it is the students' responsibility to promptly contact the instructor about it and provide the physical exam or assignment, or the e-portfolio link for verification of the completed work.

**Heed:** I allow only one week after a score has been entered into Canvas for students to contest their grade for that exam or assignment, no exceptions (this includes scores of zeros). Also, once final course grades have been submitted, no grade changes will be made of any kind unless a mistake is discovered. Thus, again, I urge students to regularly check that their grades in Canvas are up to date and accurate; this is your responsibility alone. Failure to do so may result in a final course grade lower than expected.

**Late Homework:** **No** homework assignment will be dropped or accepted late. Get your homework done on time.

**Regular Exams:** There will be 3 regular exams on the dates given below and are given on the schedule/calendar's PDF in the course's Canvas homepage. No sample regular or final exams will be given to students by the instructor for any exams (this is a Math Departmental Rule for regular exams and a course rule for Math 2270). Your (one) *lowest* regular exam score will be dropped from your total course grade; final exams cannot be dropped.

**Absence** from a regular exam will count as a zero or as the regular exam to be dropped; they cannot be taken early or late; do not ask. Absence from the final exam will count as a zero and final exams also cannot be taken early or late. You must bring a valid ID to each exam in case that you are requested to show it.

**Final Exam:** There is a mandatory, comprehensive, and proctored final exam. Its format will be paper, and pen-or-pencil, with 15 to 25 mandatory, show-your-work problems, no multiple choices. Students will show/write their work for each problem and all final exams will be graded according to the work shown. Partial credit is possible for relevant, partially correct work. Final exams are not given early or late (plan now). All students must take the final exam to pass the class. Final exams can only be taken once a semester. Final exams are not returned to students, not even upon request. The Math Department keeps final exams on record for up to a few years for data collection, samples of student work, and to help prevent cheating in following semesters.

Exam Rules: *Every* Math 2270 exam is proctored. No note cards, notes, texts, collaboration, internet devices, programming/graphing calculators, or external aid of any kind are allowed on any exam, including the final exam. Scratch paper and a standard scientific, non-graphing, non-programmable calculator are allowed, e.g., TI30 but not TI36 or higher; see the Calculator Rule below. All exam-work to be graded must be (re)written on the exam's pages itself. There are no final exam retakes and no final exam corrections of any kind can be submitted for points.

60% Final Exam Rule: The Math Department's 60% Final Exam Rule is that if a student scores less than 60% on their final exam then their total course grade will be the lower of a D or their grade as calculated according to the weights of the grading categories on the syllabus. In other words, if a student fails their final exam (scores less than 60%), then the highest total course grade that they can earn for the course is a D.

This is an important departmental rule, which must be enforced to help ensure the success of students taking courses that have Math 2270 as a prerequisite. Moreover, it enforces a reasonable standard. Rules such as this also help make, "seamless," transfers to other USHE institutions possible. Without such rules, your Math 2270 credit might not transfer to other higher ed institutions!

## The Dates and Times of

## Regular Exams and the Final Exam

**Exam 1 and 1st-homework set due:** Thursday, September 19

**Exam 2 and 2nd-homework set due:** Wednesday, October 16

**Exam 3 and 3rd-homework set due:** Thursday, November 14

**Departmental Final Exam and 4th-homework set due date:** Monday, December 9, 9:10 am – 11:10 am

(in our regular classroom unless otherwise announced in-class)

SLCC's Final Exam Schedule This link is typically for in-person classes, whose final exams are conducted according to this schedule. We include for mere convenience in case it applies.

## Math Department's Testing Rule: ***All*** **SLCC math exams, regular exams and final exams, must be taken in person in a live proctored/monitored environment for *all* modalities** (in-person, hybrid, broadcast, or online). Online and broadcast students are required to take their exams at an SLCC testing center facility or, if outside a 50-mile radius, coordinate with the Testing Center for a proctoring site nearer to their home. Any accommodations to this rule must be approved by the SLCC Math Department Associate Dean. Students are encouraged to make arrangements early in a semester with employers and families to ensure they are free during the scheduled exam periods; see the disclaimer below.

Math 2270's In-Person Testing Disclaimer: It is a student's responsibility to make arrangements early with employers, family, etc. to be free during all scheduled exams. **Missing an exam for work, for example, is not excused** as students are aware of exam dates the first day of classes. Any student not willing or not able to comply with in-person testing in their classroom, or at an SLCC Testing Center, during scheduled times should not register, or remain registered, for Math 2270.

**An Honest Note to Students:** This course consists of more than working mere rote/routine exercises by simply mimicking the text, online examples, or in-class examples. This course is an actual beginning-level theoretical mathematics course. It consists largely of putting intuitive ideas to formal mathematical definitions, surmising what must be true of our definitions, precisely formulating theorems, and constructing proofs or counterexamples to our conjectures.

Any student unwilling or unprepared to engage in the ever paramount, creative, critical, analytical, and deductive pursuit of reading and crafting valid mathematical arguments (proofs) should not take such a course. Your lack of ability and/or effort and/or time investment to understand course material, which necessarily involves reading and understanding your technical text and working through many exercises and proofs independently, is not a reflection of instructional or text quality; it reflects the student, their life, their choices/decisions, their time investments, etc.

Knowing (from memory) many definitions, theorems, and ideas behind their proofs are expected. Conducting deductive investigations and proving theorems (the underlying justifying theory), is an utterly essential and inescapable part of learning and "doing" mathematics; it is also an intensely challenging and extremely useful and ever beautiful part of the subject. I encourage you to fully engage and immerse yourself in the course material. Read and reread your well-written text and practice many of its beautiful exercises, over and over. If you do, you may learn a great deal and develop mathematically and intellectually, which is part of the purpose of such a course.

As your instructor, I will not misrepresent the subject in ways that some students may have experienced and grown accustomed in other math classes. For example, I will not present inexactly stated theorems without needed hypotheses or proof; I will not work several simple-minded examples in class and merely encourage students to mimic my steps to solutions for their homework or exam problems. Despite what you may be used to seeing in previous mathematics courses, this does not well-promote independent problem solving or learning to think mathematically, nor creatively. This course is very much "theoretical," as mentioned. I will be presenting some of the remarkable theory of elementary linear algebra during every class in course-level detail; do not be surprised by such.

**Work Ethic:** Practice is utterly crucial for learning any subject like mathematics. Keep up with the text reading and the assignments. Be prepared to ask questions on homework in

class as you will not be allowed to make-up missed homework assignments. It is highly recommended that you attend class. Mathematics is, in many respects, a language, and, like learning any language, you can learn more effectively within environments where that language is being spoken and utilized; class is such an environment. You should be prepared to spend at least two hours studying outside of class for each one hour of class time, as is standard. However, most students find that much, much more time is required to perform as well as they desire, upwards of 40 – 80 hours per week is standard depending on the number of serious science/math courses that you are taking (no kidding!). If you are unwilling/unable to make this level of investment into your intellectual and mathematical development, and your education, then you ought to seriously reconsider taking this course, and perhaps even a science major.

Students in my classes are not required to use any online homework manager (OHM). In fact, at this level, I tend to discourage this adamantly. Again, considering that mathematics is a language, you can learn it well by reading, writing, and speaking it. Students cannot submit online homework in lieu of written text homework. Your well-written book contains more practice problems than you will ever likely be able to work in a single semester. Above all, read, read, read your text until understand it, and practice many, many of its exercises. If you need extra help, ask questions in and/or out of class, and/or visit the STEM Center on the second level in SI (Redwood) for free tutoring.

Education constitutes an investment in oneself; invest all that you can while you are taking classes. One cannot buy, borrow, steal, or cheat intellectual development; if one tries, it is near obvious to others who have earned it. Like learning to master a musical instrument, one must earn it and it takes serious time and effort. Take great pride in yourself and your self-investments.

## Math 2270's Calculator Rule

Programmable calculators, graphing calculators, and any calculators capable of algebraic manipulations, are not allowed on in-class quizzes, regular exams, or the final exam.

Prohibited calculators include all the various makes of the following base models: TI36, TI83, TI84, TI86, TI89, TI92, TI-Nspire, HP48, as well as other similar models and brands. An example of an acceptable standard, scientific, non-graphing calculator is the

TI30, which is relatively inexpensive. Your instructor can verify if a calculator is acceptable for use during quizzes or exams. How to use graphing software or how to program will not be taught in Math 2270, but it will also not be assessed.

Occasionally, a standard scientific calculator, say, a TI30, is required for basic approximation of radicals, logarithmic expressions, and the like, even on exams, like the final exam. It is advised that students always have a basic calculator with them for quizzes and exams just in case that one is allowed or needed. Note that it is the instructor's prerogative to give quizzes, tests, or portions of tests that do not allow any calculator. Not having a calculator does not excuse a student from being responsible for taking a quiz or exam at the assigned time or completing problems.

Students are expected to be able to perform basic calculations such as fractional arithmetic, finding exact simplified root values, manipulating algebraic expressions at the course level, etc., without a calculator. While a few homework problems and applications may require the use of a graphing calculator or online app, e.g., Desmos, questions on in-person quizzes or exams will only test basic facts that must be demonstrated by students without aid beyond blank scratch paper and a standard, scientific, non-graphing calculator. A student's performance will be measured primarily on their understanding of the concepts and their competency in performing symbolic operations rather than a mere ability to use technology (pushing buttons) to get answers. Full credit will only be awarded on exam questions when answers are justified by a legible and valid argument.

## Grading Scale

**Grade Weights:** Your total numeric course grade will be computed according to the following categories' weights, if you score 60% or higher on the final exam (recall the 60% Final Exam Rule):

**Homework:** 20% of course's grade

**Regular Exams:** 50% of course's grade (two exams after dropping one, each exam counting 25%)

**Final Exam:** 30% of course's grade

Total numeric course grades are mapped to letter grades according to the following partition, intervals, of [0, 100%]:

| | |
|---|---|
| A [94% – 100%] | C [73% – 77%) |
| A- [90% – 94%) | C- [70 – 73%) |
| B+ [87% – 90%) | D+ [67 – 70%) |
| B [83% – 87%) | D [63 – 67%) |
| B- [80% – 83%) | D- [60 – 63%) |
| C+ [77% – 80%) | E [0% – 60%) |

Take note that grades are not “rounded up“ or curved.

**Incompletes:** Typically, incompletes are only considered when a student has completed at least 70% of total course work and is passing the class at the time the incomplete is requested. In Math 2270, this amounts to all course work being completed minus the final exam. Thus, if a Math 2270 student has completed all work except the final and is passing, then their instructor may consider, but does not have to grant, an incomplete grade to a requesting student; it is the instructor's prerogative. Incompletes are not given for more time to learn material or to avoid an undesirable grade. They are given primarily in the case of an emergency that prevented a student from being able to submit final papers/exams/etc.

## Student Conduct

Students are expected to follow the SLCC Student Code of Conduct at Student Code of Conduct.

**Classroom Deportment:** Each student is responsible for their own behavior. Any student who shows a pattern of disrespect for others, or who at any time displays egregious disrespect for others, will be subject to penalties as per the student code of conduct.

**Attendance:** Class attendance and/or participation, whether in-person, broadcast, or online, are expected. They are typically essential to achieve satisfactory results. It is the student's responsibility to be aware of all material covered, in-class announcements, tests dates, assignment due dates, etc.

**Electronic Devices in the Classroom:** Absolutely no video or audio recording in the classroom is allowed without prior written authorization from the instructor. Cell phones and other electronic devices should be in silence mode during classes, tests, and final exams. Moreover, such devices should not be on desks during lectures, tests, and the final exam unless they are part of class participation activities.

**Cell Phones and Tech in Class**: In case of emergency, or otherwise, students should exit the classroom before they e-mail, text, or use their cell phones. If students choose to use a computer or electronic device in class to take notes, they may do so without distracting their classmates. Computer activities that are not directly related to the class should not be done in-class, e.g., watching YouTube or the like. Students who text, scroll on their phones, talk on their cell phone, or use their computers to do activities not directly related to the class will be asked to leave the classroom.

**Math 2270's Cheating Rule:** Cheating on any assignment or exam will minimally result in a failing grade of 0% for that assignment without any possibility for that work to be made up, resubmitted, or for the failing grade to be substituted by any other work's grade. Moreover, cheating on a single assignment or exam can result in a failing grade for the entire class; this is typically the prerogative of the individual instructor. Cheating is not tolerated, so, take heed and do honest work to learn and develop intellectually. For more details about academic dishonesty, consult the Student Code of Conduct, where this topic is addressed in section C (see below too):

*Policies and Student Affairs*.

**Sanctions for Academic Misconduct** (taken from the Student Code of Conduct): Faculty, program directors, associate deans, deans, and the provost for Academic Affairs are authorized to impose any one or a combination of the following sanctions after finding a student responsible for acts of academic misconduct. The possible sanctions include, but are not limited to

- verbal warning and reprimand,
- restriction of privileges, such as access to lab facilities, library facilities, or testing centers,
- failure of the exam, quiz, project, or other assessment,
- failure for the course,
- withdrawal from the course, or
- withdrawal from the academic program.

Upon the circumstance of catching a student cheating, even if the infraction seems minor or the student is remorseful, instructors are expected to fill out the following form (the Dean of Students uses these forms to establish patterns of behavior):

## Academic Misconduct Violation Reporting Form.

## College-Wide Student Learning Outcomes

Math 2270's College-Wide Student Learning Outcomes mapped to SLCC College-Wide & General Education SLOs.

1. Acquire substantive knowledge
2. Communicate effectively manner
3. Develop quantitative literacies
4. Think critically & creatively
5. Become a community engaged learner
6. Work in a professional & constructive
7. Develop computer & information literacy
8. Develop lifelong wellness

| Learning Outcomes | SLCC CWSLO # |
|---|---|
| Solve linear systems using elementary row operations, elementary matrices, and inverse matrices, and Cramer's rule. | 1,3,4 |
| Compute determinants, minors, cofactors, inverse matrices using multilinearity, alternating, and skew symmetric properties of determinants. | 1,3,4 |

| | |
|---|---|
| Determine/prove real and/or complex linear spaces and linear algebras (including but not limited to matrix algebra), subspaces, null spaces, row/column spaces of matrices, linear independence, span, bases, change of bases. | 1,2,3,4 |
| Determine general linear transformations, e.g., the differential operator and definite integral, not just matrix transformations, but also finite-dimensional matrix representations. | 1,3,4 |
| Determine eigenvalues, bases of general eigenvectors, similarity of matrices, diagonalizable matrices, and apply the Cayley-Hamilton theorem. | 1,3,4 |
| Determine real and/or complex inner product spaces, orthogonal projections, and apply the Gram-Schmidt process. | 1,3,4 |
| | |
| | |

## Assignment Schedule

| Due Date | Assignment Name | Assignment Type | Points |
|---|---|---|---|
| | book | Discussion | 0 |
| | exam 1 | Assignment | 100 |
| | exam 2 | Assignment | 100 |
| | exam 3 | Assignment | 100 |
| | final exam | Assignment | 100 |

| Due Date | Assignment Name | Assignment Type | Points |
|---|---|---|---|
| | hw 1 and project/supplemental problems | Assignment | 25 |
| | hw 2 and project/supplemental problems | Assignment | 25 |
| | hw 3 and project/supplemental problems | Assignment | 25 |
| | hw 4 and project/supplemental problems | Assignment | 25 |
| | Introduce Yourself | Discussion | 0 |

## How to Navigate to Canvas

## Institutional Policies

As members of our academic community, we would like to invite you to review the Institutional Syllabus which covers important policies and procedures. This document contains important links for students on the code of student rights and responsibilities, academic integrity, and grading policies, Title IX and other important acknowledgements. By familiarizing yourself with this information, you can help us create a safe and respectful environment for everyone.

You can access the document by clicking on the following link: https://slcc.instructure.com/courses/530981/pages/institutional-syllabus

## Learning Support and Tutoring Services

We are pleased to offer a range of tutoring and learning support services to help you achieve your academic goals. Whether you need assistance with a specific subject or want to improve your study skills, you have many options for tutoring or other support.

To learn more about the services we offer and how to access them, please visit the Institutional Syllabus under the Tutoring and Learning Support tab: https://slcc.instructure.com/courses/530981/pages/institutional-syllabus. We encourage you to take advantage of these resources to help you succeed in your studies. If you have any questions or would like to schedule a tutoring session, please don't hesitate to reach out to us. We are here to support you in any way we can.

## Advising and Counseling Support Services

At our institution, we are committed to supporting your academic and personal growth. That's why we offer a range of advising and counseling services to help you navigate the challenges of college life. To learn more about the resources available to you and how to access them, please visit the Institutional Syllabus under the Advising and Counseling Support Services tab: https://slcc.instructure.com/courses/530981/pages/institutional-syllabus. Our advising team and the support centers across campus are here to support you in achieving your goals and overcoming any obstacles you may face.

## Student Academic Calendar

As students you should be aware of all important dates in the semester, such as the day that courses begin and end, as well as the drop date and the last day to withdraw. To learn more about those dates, navigate to the Student Academic Calendar below:

SLCC Student Academic Calendar

## Contingency Remote Workday/Learning Plan

Under Utah legislation, the governor can now call a "Remote Workday" given certain circumstances. These remote workdays can be due to inclement weather, pollution, or natural disasters.

1. Each math instructor (full or part-time) will **check-in/communicate** with the Math AD, say, with an email that acknowledges the remote workday and their relative plan for it.
2. The Math AD will verify whether a class will still meet on a campus if something happens at the campus, etc.
3. Each instructor will make a **Canvas class announcement and communicate with students**, informing them of the remote learning day and what their relative plan is for the day's class. Announcements will include pertinent info for the remote day and/or any adjustments to the next class:

- What are the assigned readings, video lectures to watch, practice problems to work?
- Is the instructor holding a Zoom meeting in lieu of the in-person class? The Zoom meeting must be optional and should be conducted at the same time as the regularly scheduled class, if possible. Moving to livestream modality is only an option, not required of the instructor or students. The Zoom meeting could simply be to answer student questions.
- Any test that was scheduled on a remote learning day will be postponed, either to the next class or possibly later scheduled through the Testing Center. Instructors will let students know that the exam has been postponed in their Canvas announcement.

## General Learning Support & Tutoring Services

General Learning Support & Tutoring Services provide support for SLCC students enrolled in any class at the College. You may also ask your instructor about discipline-specific learning support and tutoring services. The following resources are provided free-of-charge.

- In your Canvas course, there is a (blue) tab, "Online Tutoring," in the left column of tabs. This literally provides free online tutoring during hours of operation.
- For in-person Redwood campus help in math, the next resource is highly recommended: **STEM Center** in SI building, which offers free STEM tutoring.

STEM Center Hours (may vary by semester): Monday-Thursday, 10:00 a.m.-9:00 p.m. Friday and Saturday, 10:00 a.m.-5:00 p.m.

Tutoring: This is an index of tutoring resources.

STEM Learning Centers: Provides free assistance in Math, Science, Accounting, CSIS and Allied Health Classes at 6 campus locations.

Student Writing Center: Provides in-person and online feedback on all writing assignments.

Library Services: Provides research help, print and online resources, computers and study space.

ePortfolio Lab: Provides drop-in assistance for all ePortfolio questions.

eLearning Support: Provides support for navigating online and hybrid classes.

**Accessibility and Disability Services:** If you have a disability and want an accommodation, please contact:

- Phone: 801-957-4659
- Email: ADS@slcc.edu
- Website: ADS

**Testing Accommodations:** Students taking their exams through the DRC or the Testing Center's services, must take all corresponding exams on the scheduled exam dates listed above and their scheduled exam times must overlap the class's scheduled exam time; failure to do so may result in your exam not being accepted. Thus, you cannot schedule your exam a day or two early, or late, or several hours before, or after, the time that the rest of your class takes the exam without prior instructor permission. It is your responsibility to schedule your exam's days and times with the Testing Center well-ahead; you already know their dates and times.

**HEED:** Testing Center Instructions for Accommodated Student Appointments: Before scheduling with the Testing Center, accommodated students must send their instructor a Canvas message 5 days before each exam with their S# expressing their intent to take the relevant exam in the Testing Center; you will not be able to schedule an accommodated exam with the Testing Center otherwise. Your instructor must submit each accommodated exam to the Testing Center but will not know to do this unless the student requests this of them directly in a Canvas message (include your S#).

After the Testing Center has setup an accommodated exam for you, go to **MySLCC**—Testing Services Card (search for 'Testing Services' in 'Discover More' at the bottom of the page if this is not pinned to your Home Page. Click on preferred testing center: Redwood, Jordan, or South City. In RegisterBlast, please select 'Accommodated Testing' in the drop-down menus on the left and look for your exam, e.g., Math 2270.xxx Exam ADA – A.Costello. Input your S number (without the S) to finalize the appointment. If you need more help, please visit the Testing Center's homepage or in person.

For more info, contact the Testing Center/Services.

## Course Coverage/Topics

As mentioned above, Math 2270 will adequately prepare passing students for a subsequent course in Ordinary Differential Equations, e.g., Math 2280, and further courses in beginning abstract algebra, e.g., group/ring/field theory.

Topics in Math 2270 include but are not limited to:

- Real and complex linear systems
- Elementary row operations, echelon forms, possible echelon forms of square matrices
- Homogeneous linear systems, undetermined homogeneous linear systems (more unknowns than equations) have nontrivial solutions
- Matrix linear algebra over the real or complex numbers, including proof that square matrices form a complex, associative linear algebra with identity, e.g., the matrix-multiplicative associative property and the distributive properties.

- Proofs of several basic properties of square matrices, e.g., the trace of a product is the trace of the transposed product, which is useful when investigating invariants of similar matrices
- Multilinear functions, alternating, and skew-symmetric properties (their equivalence), determinants, Laplace row/column expansions and proof of their equality, determinant simplifications using row operations, Vandermonde/Wronskian determinants
- Elementary matrices, permutation matrices, and many relevant important properties, e.g., the Cauchy Determinant theorem: determinants are multiplicative homomorphisms.
- Proof of the general adjoint formula, and as immediate consequences, proofs a general formula for the inverse of any nonsingular square matrix over the real or complex numbers and the general Cramer's rule
- Linear spaces over the reals or complex field

1. Definition of a linear/vector space and closure of operations, subspaces, e.g., the intersection of an arbitrary number of subspaces, the smallest subspace generated by a subset of the linear space
2. Span of vectors, linear independence, bases (all finite or not), and finite-dimension theory with infinite-dimension theory optional (requires Math 2200, cardinal numbers and the Schröder-Berstein Theorem)

- The general definition of a real or complex, associative, commutative linear algebra with identity, contrasting with mere linear spaces
- Changing bases (with mention of the Frenet frame, curvature, and torsion in Multivariate Calculus)
- Use RREFs in row and column spaces to determine bases and vector dependency equations in finite dimensional linear spaces.
- Real inner-product spaces, including the dot product, vector projections, and prove many relevant properties, e.g., linearity, a generalized law of Cosines, the Cauchy-Schwartz inequality, the triangle inequality, the Gram-Schmidt process. Complex inner-product spaces are optional
- Cross products, their linearity, their magnitude formula, determinants compute volumes of parallelepipeds in 3-dimensions with the box-product formula. Volumes

of n-dimensional parallelepipeds with determinants (scissor congruence) and/or Gram-Schmidt process is optional

- Additive homomorphisms, monomorphisms, endomorphisms, isomorphisms, automorphisms, and linear transformations over the real or complex numbers, e.g., rotations, logarithms/exponential functions, derivatives, linear functionals, like definite integrals, and the Fundamental Theorem of finite dimensional real linear spaces, which says that every n-dimensional vector space is isomorphic to Rn or Cn, the structure of linear spaces
- Kernel and image subspaces of linear transformations, one-to-one is equivalent to a trivial kernel, linear equations, and inverse images (solution spaces) are affine kernels
- Fundamental spaces of a matrix, the rank-plus-nullity theorem; more generally, the perp space of a subspace, and proof that the dimension of the subspace plus its perp space's dimension is the dimension of the whole space.
- Every linear transformation of a finite dimensional linear space is represented by matrix multiplication, which depends on a specific ordered base. This leads naturally to the equivalence relation of similar matrices, and matrix diagonalization
- Eigenvalues and eigenvectors of general linear transformations, e.g., the derivative operator, (square) matrix induced transformations. The trace/sum and det/product formulas of eigenvalues of a square matrix
- Important "near" optional topics that are needed in the sequel Math 2280, Ordinary Differential Equations (ODEs), include the linear algebra isomorphism of polynomial-derivative operators to polynomials, the Cayley-Hamilton Theorem, and that every nxn matrix has n many generalized eigenvectors
- Quadratic forms, positive/negative definite matrices, and the method of least squares are also optional topics