Linear Algebra

SECTION I: Course Overview

Course Code: MATH250CDG
Subject Area(s): Mathematics
Prerequisites: See Below
Language of Instruction: English
Total Contact Hours: 60
Recommended Credits: 4

COURSE DESCRIPTION

In this course, we will cover material related principally to linear systems of equations, vector spaces, and linear transformations. Solving systems of linear equations is a basic tool of many mathematical procedures used for solving problems in science and engineering. The content of this course will thus focus on the mathematical theory and methods of linear algebra.

LEARNING OBJECTIVES

Upon successful completion of this course, you will be able to:

- Execute mathematical expressions specific to linear algebra: solving linear equations, performing matrix algebra through Gauss-Jordan elimination, calculating determinants, and finding eigenvalues and eigenvectors.
- Relate a matrix as a linear transformation relative to a basis of a vector space and understand the difference between span and basis.
- Understand image, kernel, nullity, and rank.
- Recognize the inner product as the definite integral from calculus.
- Describe the concept of orthogonality of vectors, the Gram-Schmidt procedure, and QR factorization.

PREREQUISITES

Before enrollment, this course requires you to have completed Calculus III.

SECTION II: Instructor & Course Details

INSTRUCTOR DETAILS

Name: TBA
Contact Information: TBA
Term: SUMMER

ATTENDANCE POLICY

This course will meet four times per week for 125 minutes per session. This course is comprised of 24 total class sessions.

CEA enforces a mandatory attendance policy. You are therefore expected to attend all regularly scheduled class sessions, including any field trips, site visits, guest lectures, etc. that are assigned by the instructor. The table below shows the number of class sessions you may miss before receiving a grade penalty.

ALLOWED ABSENCES – SUMMER		
Courses Meeting X day(s) Per Week	**Allowed Absence(s)**	**Automatic Failing Grade at Xth absence**
Courses meeting **4** day(s) per week	**1** Absence	**4th** Absence

For every additional absence beyond the allowed number, your final course grade will drop down to the subsequent letter grade (ex: A+ to A). As a student, you should understand that the grade penalties will apply if you are marked absent due to tardiness or leaving class early. In the table below, you will find the grade penalty associated with each excessive absence up to and including automatic course failure.

ATTENDANCE DOCKING PENALTIES				
Absence	**1st**	**2nd**	**3rd**	**4th**
Penalty	**No Penalty**	**0.5 Grade Docked**	**1 Grade Docked**	**Automatic Failure**
HIGHEST POSSIBLE GRADE AFTER ATTENDANCE PENALTIES				
Grade	**A+**	**A**	**A-**	**F**

CEA does not distinguish between excused and unexcused absences. As such, no documentation is required for missing class. Similarly, excessive absences, and the grade penalty associated with each, will not be excused even if you are able to provide documentation that shows the absence was beyond your control. You should therefore only miss class when truly needed as illness or other unavoidable factors may force you to miss a class session later on in the term.

GRADING & ASSESSMENT

The instructor will assess your progress towards the above-listed learning objectives by using the forms of assessment below. Each of these assessments is weighted and will count towards your final grade. The following section (Assessment Overview) will provide further details for each.

Class Participation	**10%**
Homework	**15%**
Quizzes	**25%**
Midterm Examination	**25%**
Final Examination	**25%**

The instructor will calculate your course grades using the CEA Grading Scale shown below. As a CEA student, you should understand that credit transfer decisions–including earned grades for courses taken abroad–are ultimately made by your home institution.

CEA GRADING SCALE			
Letter Grade	**Numerical Grade**	**Percentage Range**	**Quality Points**
A+	9.70 – 10.0	97.0 – 100%	4.00
A	9.40 – 9.69	94.0 – 96.9%	4.00
A-	9.00 – 9.39	90.0 – 93.9%	3.70
B+	8.70 – 8.99	87.0 – 89.9%	3.30
B	8.40 – 8.69	84.0 – 86.9%	3.00
B-	8.00 – 8.39	80.0 – 83.9%	2.70
C+	7.70 – 7.99	77.0 – 79.9%	2.30
C	7.40 – 7.69	74.0 – 76.9%	2.00
C-	7.00 – 7.39	70.0 – 73.9%	1.70
D	6.00 – 6.99	60.0 – 69.9%	1.00
F	0.00 – 5.99	0.00 – 59.9%	0.00
W	Withdrawal	N/A	0.00
INC	Incomplete	N/A	0.00

ASSESSMENT OVERVIEW

This section provides a brief description of each form of assessment listed above. Your course instructor will provide further details and instructions during class time.

Class Participation (10%): Student participation is mandatory for all courses taken at a CEA Study Center. The instructor will use the rubric below when determining your participation grade. All students should understand that attendance and punctuality are expected and will not count positively toward the participation grade.

CLASS PARTICIPATION GRADING RUBRIC	
Student Participation Level	**Grade**
You make major & original contributions that spark discussion, offering critical comments clearly based on readings, research, & theoretical course topics.	**A+** (10.0 – 9.70)
You make significant contributions that demonstrate insight as well as knowledge of required readings & independent research.	**A/A-** (9.69 – 9.00)
You participate voluntarily and make useful contributions that are usually based upon some reflection and familiarity with the required readings.	**B+/B** (8.99 – 8.40)
You make voluntary but infrequent comments that generally reiterate the basic points of the required readings.	**B-/C+** (8.39 – 7.70)
You make limited comments only when prompted and do not initiate debate or show a clear awareness of the importance of the readings.	**C/C-** (7.69 – 7.00)
You very rarely make comments and resist engagement with the subject. You are not prepared for class and/or discussion of course readings.	**D** (6.99 – 6.00)
You make irrelevant and tangential comments disruptive to class discussion. You are consistently unprepared for class and/or discussion of the course readings.	**F** (5.99 – 0.00)

Homework (15%): Homework is assigned on average once a week, to be handed in one week later. Please write the homework question before showing, in complete steps, the solution, and do not forget to consider any modifications to problem sets announced in class. The homework is due at the date scheduled independent of the schedule of lectures.

Quizzes (25%): Students will be given a quiz each week on the homework that is due. There will be 9 quizzes.

Midterm Exam (25%): One midterm exam will be given during the 12th session of class.

Final Examination (25%): A comprehensive final examination during the last week of classes.

REQUIRED READINGS

Reading assignments for this course will come from the required text(s) and/or the selected reading(s) listed below. All required readings–whether assigned from the text or assigned as a selected reading–must be completed according to the due date assigned by the course instructor.

I. **REQUIRED TEXT(S)**: You may purchase or acquire the required text(s) before departure or upon program arrival. The required text(s) are listed below:

Lay, David C., Lay, Steven R., McDonald, Judy J. *Linear Algebra and Its Applications*, 5th ed.

RECOMMENDED READINGS

The recommended reading(s) and/or text(s) for this course are below. These recommended readings are not mandatory, but they will assist you with research and understanding course content.

Strang, Gilbert. *Linear Algebra and Its Applications*, 4th ed.

Edwards, Jr, C.H. and Penney, David E. *Elementary Linear Algebra*, 1st ed.

ADDITIONAL RESOURCES

In order to ensure your success abroad, CEA has provided the academic resources listed below. In addition to these resources, each CEA Study Center provides students with a physical library and study areas for group work. The Academic Affairs Office at each CEA Study Center also compiles a bank of detailed information regarding libraries, documentation centers, research institutes, and archival materials located in the host city.

- **UNH Online Library**: As a CEA student, you will be given access to the online library of CEA's School of Record, the University of New Haven (UNH). You can use this online library to access databases and additional resources while performing research abroad. You may access the UNH online library here or through your MyCEA Account. You must comply with UNH Policies regarding library usage.

- **CEAClassroom – Moodle**: CEA instructors use Moodle, an interactive virtual learning environment. This web-based platform provides you with constant and direct access to the course syllabus, daily schedule of class lectures and assignments, non-textbook required readings, and additional resources. Moodle includes the normal array of forums, up-loadable and downloadable databases, wikis, and related academic support designed for helping you achieve the learning objectives listed in this syllabus.

  During the first week of class, CEA academic staff and/or faculty will help you navigate through the many functions and resources Moodle provides. While you may print a hard copy version of the syllabus, you should always check Moodle for the most up-to-date information regarding this course. The instructor will use Moodle to make announcements and updates to the course and/or syllabus. It is your responsibility to ensure that you have access to all Moodle materials and that you monitor Moodle on a daily basis in case there are any changes made to course assignments or scheduling.

  To access Moodle: Please log-in to your MyCEA account using your normal username and password. Click on the "While You're Abroad Tab" and make sure you are under the "Academics" sub-menu. There you will see a link above your schedule that says "View Online Courses" select this link to be taken to your Moodle environment.

COURSE CALENDAR *Linear Algebra*			
SESSION	**TOPICS**	**ACTIVITY**	**READINGS & ASSIGNMENTS**
1	**Ch. 1 – Linear Equations in Linear Algebra**	Lecture and In-class problem solving on: 1.1 Systems of Linear Equations – *Matrix Notation, Solving a Linear System, Existence and Uniqueness* 1.2 Row Reduction End Echelon Forms – *The Row Reduction Algorithm, Pivoting, Solutions to Linear Systems, Back-Substitution* 1.3 Vector Equations – Vectors in $\mathbb{R}^2$, *Geometric Descriptions of* $\mathbb{R}^2$, *Vectors in* $\mathbb{R}^3$, $\mathbb{R}^n$, *Linear Combinations, Span* $\{\boldsymbol{v}\}$ *and Span* $\{\boldsymbol{u}, \boldsymbol{v}\}$	Read Ch. 1 **HW 1 Assigned**
2	**Ch. 1 – Linear Equations in Linear Algebra**	Lecture and In-class problem solving on: 1.4 The Matrix equation $\boldsymbol{Ax} = \boldsymbol{b}$ – *Existence of Solutions, Properties of the Matrix-Vector Product* $\boldsymbol{Ax}$ 1.5 Solution Sets of Linear Systems – *Trivial and Non-trivial Solutions, Parametric Vector Form, Non-Homogeneous Systems* 1.6 Applications of Linear Systems – *Economics, Chemical Equations, Network Flow*	Read Ch. 1
3	**Ch. 1 – Linear Equations in Linear Algebra**	**Quiz # 1 – HW 1** Lecture and In-class problem solving on: 1.7 Linear Independence – *LI of Matrix Columns, Sets of One or Two or More Vectors* 1.8 Introduction to Linear Transformations – *Matrix Transformations, Shear Transformations, Contraction and Dilation*	**HW 1 Due** Read Ch. 1 **HW 2 Issued**
4	**Ch. 1 – Linear Equations in Linear Algebra** **Ch. 2 – Matrix Algebra**	Lecture on: 1.9 The Matrix of Linear Transformations – *Standard Matrix for LT, Geometric Linear Transformations* 2.1 Matrix Operations – *Matrix Multiplication, Properties, The Transpose*	Read Ch. 2
5	**Ch. 2 – Matrix Algebra**	**Quiz # 2 – HW 2** Lecture and In-class problem solving on:	**HW 2 Due** Read Ch. 2 **HW 3 Issued**

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		2.2 The Inverse of a Matrix – *Singular, Non-singular, The Determinant, Elementary Matrices, An Algorithm to Finding* A^{-1} 2.3 Characterizations of Invertible Matrices – *The Invertible Matrix Theorem, Invertible Linear Transformations*	
6	**Ch. 2 – Matrix Algebra**	2.4 Partitioned Matrices – *Multiplication, Inverses* 2.5 Matrix Factorizations – *The LU Factorization, Applications to Electrical Engineering, Computer Science*	Read Ch. 2
7	**Ch. 2 – Matrix Algebra**	**Quiz # 3 – HW 3** Lecture and In-class problem solving on: 2.8 Subspaces of $\mathbb{R}^n$ – *Column Space and Null Space, Basis for a Subspace* 2.9 Dimension and Rank – *Coordinate Systems, The Dimension of Subspace, The Invertible Matrix Theorem Continued*	**HW 3 Due** Read Ch. 2 **HW 4 Issued**
8	**Ch. 3 – Determinants**	Lecture and In-class problem solving on: 3.1 Introduction to Determinants – Cofactor Expansion 3.2 Properties of Determinants – Row Operations, Column Operations, Linearity Property of the Determinant Function	Read Ch. 3
9	**Ch. 3 – Determinants**	**Quiz # 4 – HW 4** Lecture and In-class problem solving on: 3.3 Cramer's Rule, Volume, and Linear Transformations – *An Inverse Formula, Applications to Engineering*	**HW 4 Due** Read Ch. 3 **HW 5 Issued**
10	**Ch.4 – Vector Spaces**	Lecture and In-class problem solving on: 4.1 Vector Spaces and Subspaces – *Definitions, A Subspace Spanned by a Set* 4.2 Null Spaces, Column Spaces, and Linear Transformations – *Definitions, The Contrast between Null Space and Column Space, The Kernel and Range of a Linear Transformation*	Read Ch. 4

11	**Ch.4 – Vector Spaces**	**Quiz # 5 – HW 5** Lecture and In-class problem solving on: 4.3 Linear Independent Sets: Bases – *The Standard Basis, The Spanning Set Theorem, Bases for* $\mathtt{Nul}\ A$ *and* $\mathtt{Col}\ A$ 4.4 Coordinate Systems – *A Graphical Interpretation of Coordinates, Coordinates in* $\mathbb{R}^n$*, The Coordinate Mapping*	**HW 5 Due** Read Ch. 4
12	**MIDTERM EXAM**		
13	**Ch.4 – Vector Spaces**	Lecture and In-class problem solving on: 4.5 The Dimensions of a Vector Space – *Finite Dimensional versus Infinite Dimensional, The Dimensions of* $\mathtt{Nul}\ A$ *and* $\mathtt{Col}\ A$ 4.6 Rank – *The Row Space, The Rank Theorem, Nullity, The Rank and the Invertible Matrix Theorem*	Read Ch. 4
14	**Ch.4 – Vector Spaces** **Ch.5 – Eigenvalues and Eigenvectors**	Lecture and In-class problem solving on: 4.7 Change of Basis – *In* $\mathbb{R}^n$ 5.1 Eigenvectors and Eigenvalues - *Definitions*	Read Ch. 4 **HW 6 Issued**
15	**Ch.5 – Eigenvalues and Eigenvectors**	Lecture and In-class problem solving on: 5.2 The Characteristic Equation – *Determinants, Properties of Determinants, Similarity, Applications to Dynamical Systems* 5.3 Diagonalization – *The Diagonalization Theorem, Non-distinct Eigenvalues*	Read Ch. 5
16	**Ch.5 – Eigenvalues and Eigenvectors**	**Quiz #6 – HW 6** Lecture and In-class problem solving on: 5.4 Eigenvectors and Linear Transformations – *The Matrix of a Linear Transformation, Linear Transformations from V into V, Linear Transformations on* $\mathbb{R}^n$*, Similarity of Matrix Representations* 5.5 Complex Eigenvalues – *Real and Imaginary Parts of Vectors, Eigenvalues and Eigenvectors of a Real Matrix that Acts on* $\mathbb{C}^n$	**HW 6 Due** Read Ch. 5 **HW 7 Issued**

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17	**Ch.5 – Eigenvalues and Eigenvectors**	Lecture and In-class problem solving on: 5.6 Discrete Dynamical Systems – *A Predator-Prey System, Graphical Descriptions of Solutions, Change of Variable, Survival of the Spotted Owl* 5.7 Applications to Differential Equations – *The Fundamental Set of Solutions, An Initial Value Problem, Stability, Complex Eigenvalues*	Read Ch. 5
18	**Ch.5 – Eigenvalues and Eigenvectors**	**Quiz #7 – HW 7** Lecture and In-class problem solving on: 5.8 Iterative Estimates for Eigenvalues – *The Power Method, The Inverse Power Method*	**HW 7 Due** Read Ch. 5 **HW 8 Issued**
19	**Ch.6 – Orthogonality and Least Squares**	Lecture and In-class problem solving on: 6.1 Inner Product, Length, and Orthogonality – *The Dot Product, The Length of a Vector, Distance in* $\mathbb{R}^n$*, Orthogonal Vectors, Orthogonal Complements* 6.2 Orthogonal Sets – *Orthogonal Basis, An Orthogonal Projection, A Geometric Interpretation, Orthonormal Sets*	Read Ch. 6
20	**Ch.6 – Orthogonality and Least Squares**	**Quiz #8 – HW 8** Lecture and In-class problem solving on: 6.3 Orthogonal Projections – *The Orthogonal Decomposition Theorem, A Geometric Interpretation of the Orthogonal Projection, Properties of Orthogonal Projections, The Best Approximation Theorem* 6.4 The Gram-Schmidt Process – *Orthonormal Bases, QR Factorization of Matrices, Difference between LU Factorization and QR Factorization*	**HW 8 Due** Read Ch. 6 **HW 9 Issued**
21	**Ch.6 – Orthogonality and Least Squares**	Lecture and In-class problem solving on: 6.5 Least-Squares Problems – *Solution of the Least-Squares Problem, The Least-Squares Error, Alternative Calculations of the L-S Solutions* 6.6 Applications to Linear Models – *The General Linear Model, L-S Fitting of Other Curves, Multiple Regression*	Read Ch. 6

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22	**Ch.6 – Orthogonality and Least Squares**	**Quiz #9 – HW 9** Lecture and In-class problem solving on: 6.7 Inner Product Spaces – *Lengths, Distances, and Orthogonality, The Cauchy-Schwarz Inequality, The Triangle Inequality, Calculus Method of Inner Product* 6.8 Applications to Inner Product Spaces – *Weighted Least-Squares, Trend Analysis of Data, Fourier Series*	**HW 9 Due** Read Ch. 6 **HW 10 Issued**
23	**Ch.7 – Symmetric Matrices and Quadratic Forms**	**HW 10** Lecture and In-class problem solving on: 7.1 Diagonalization of Symmetric Matrices – *The Spectral Theorem, Spectral Decomposition* 7.4 The Singular Value Decomposition – *More on the Invertible Matrix Theorem, Applications*	Read Ch. 7 **HW 10 Due**
24	**FINAL EXAM**		

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SECTION III: CEA Academic Policies

The policies listed in this section outline general expectations for CEA students. You should carefully review these policies to ensure success in your courses and during your time abroad. Furthermore, as a participant in the CEA program, you are expected to review and understand all CEA Student Policies, including the academic policies outlined on our website. CEA reserves the right to change, update, revise, or amend existing policies and/or procedures at any time. For the most up to date policies, please review the policies on our website.

Class & Instructor Policies can be found here
General Academic Policies can be found here