Syllabus for
MAT 312—Linear and Matrix Algebra
3 Credit Hours
Summer 2017

I. COURSE DESCRIPTION

A study of vector spaces, systems of equations, linear transformations, matrices, determinants, and applications.
Prerequisite: MAT 202.

II. COURSE GOALS

The purpose of this course is to enable the student to do the following:

A. Conceive of a vector space as an abstract mathematical system that incorporates many of the more elementary mathematical models.

B. Gain an understanding of the introduction of abstract mathematics.

C. Gain an understanding of mathematical tools for handling problems that involve matrices, especially for students of social and physical science.

III. STUDENT LEARNING OUTCOMES FOR THIS COURSE

A. Terminal Objectives
As a result of successfully completing this course, the student will be able to do the following:
1. Explain matrix algebra and matrix operations.
2. Solve systems of algebraic equations using matrix techniques.
3. Define and manipulate vector spaces.
4. Solve eigenvalue problems.

B. Unit I Objective
The objective of Unit I is to review systems of equations, matrix representation of systems of equations, and applications of systems of equations. Students are introduced to geometric vectors, vector operations, vector equations, and matrix equations in the context of coordinate spaces. Ideas studied include coordinate equations, parametric equations, spanning sets, linear independent sets, and linear dependence. As a result of successfully completing this unit, the student will be able to do the following:
1. Write a system of equations in matrix forms. (Subj. Comp. 8)
2. Reduce a matrix to non-echelon form. (Subj. Comp. 8)
3. Solve a system with matrix manipulation. (Subj. Comp. 8)
4. Write coordinate and parametric equations, linear transformations, and matrix representation of linear transformation relative to natural basis. (Subj. Comp. 6, 8)
5. Test a set to see if it is linearly independent and spans a given set of vectors. (Subj. Comp. 6, 8)
6. Find the coordinates of vector space. (Subj. Comp. 8)
7. Find the coordinates of a vector relative to a given basis. (Subj. Comp. 8)

C. Unit II Objective
The objective of Unit II is matrix algebra: matrix operations are considered. Students learn to add, subtract, multiply, invert, and transpose matrices. Scalar multiplication is introduced, and students learn properties that express relationships between all

operations. Properties of invertible matrices that unify the content of linear algebra are identified. Determinants are introduced and used to describe solutions to systems of equations. Matrices are both partitioned and factored. As a result of successfully completing this unit, the student will be able to do the following:

1. Perform matrix operations. (Subj. Comp. 8)
2. Verify properties of matrix operations:
    a. Associative properties (Subj. Comp. 5, 6, 8)
    b. Existence of multiplicative identify (Subj. Comp. 5, 8)
    c. Existence of additive neutral element (Subj. Comp. 5, 8)
    d. Existence of additive inverse (Subj. Comp. 5, 8)
    e. Commutative property of addition (Subj. Comp. 5, 8)
3. Demonstrate non-commutativity of multiplication. (Subj. Comp. 5, 8)
4. Use properties of a matrix to evaluate its determinant. (Subj. Comp. 6, 8)
5. Use knowledge of determinants to characterize
    a. Solution to system of equations (Subj. Comp. 7, 8)
    b. Existence of inverse (Subj. Comp. 7, 8)
6. Use adjoint procedure for finding the inverse of an invertible matrix. (Subj. Comp. 5, 8)
7. Use matrices to find area and volumes of figures from analytical geometry. (Subj. Comp. 5, 6, 7, 8)

D. Unit III Objective

The objective of this unit abstracts the idea of vector space. Characteristics of subspaces are considered. Special subspaces, null space, column spaces, row spaces, and range spaces are studied. Basis for a vector space is defined and coordinate spaces determined by bases are considered. This unit considers linear transformations. Properties of linear transformations are considered, matrices that represent linear transformations are found, and bases that diagonalize the matrix of a transformation are found, providing such bases exist. As a result of successfully completing this unit, the student will be able to do the following:

1. Define a vector space. (Subj. Comp. 8)
2. Define and give an example of subspaces. (Subj. Comp. 8)
3. Find a basis for a vector space. (Subj. Comp. 8)
4. Find coordinates of a vector relative to a basis. (Subj. Comp. 8)
5. Explain how changing bases affects coordinates. (Subj. Comp. 8)
6. Find transition matrices that change bases. (Subj. Comp. 6, 7, 8)
7. Give the defining attributes of a linear transformation. (Subj. Comp. 5, 8)
8. Find the Range and Null space of a linear transformation. (Subj. Comp. 8)
9. Find a matrix for a linear transformation. (Subj. Comp. 8)
10. Find bases for null and column spaces. (Subj. Comp. 8)
11. Find transition matrices that express connections between different matrices of the same transformation. (Subj. Comp. 6, 8)
12. State when a diagonal matrix representation of a linear transformation can be found. (Subj. Comp. 8)
13. Find a basis that causes the matrix of a linear transformation to be diagonal, providing the diagonal matrix exists. (Subj. Comp. 6, 8)

E. Objectives for Students in Teacher Preparation Programs

The course goals for the Teacher Preparation Program now meet the "competency-based" requirements established by the Oklahoma Commission on Teacher Preparation. This course meets Subject Competencies 5, 6, 7, and 8.

Subject Competencies

SC5: Has a broad and deep knowledge of the concepts, principles, techniques, and reasoning methods of mathematics that is used to set curricular goals and shape teaching.

SC6: Understands significant connections among mathematical ideas and the applications of these ideas to problem solving in mathematics, in other disciplines, and in the world outside of school.

SC7: Has experiences with practical applications of mathematical ideas and is able to incorporate these in curricular and instructional decisions.

SC8: Is proficient in, at least, the mathematics content needed to teach the mathematics skills described in Oklahoma's core curriculum, from multiple perspectives. This includes, but is not limited to, a concrete and abstract understanding of number systems and number theory, geometry and measurement, statistics and probability, functions, algebra, discrete mathematics, and calculus necessary to effectively teach the mathematics skills addressed in the sixth through twelfth grade in the Oklahoma core curriculum. (The depth and breadth of knowledge should be much greater than for the Intermediate Mathematics certification.)

IV. TEXTBOOKS AND OTHER LEARNING RESOURCES

A. Required Materials

1. Textbooks

   Lay, David C. *Linear Algebra and Its Applications.* 3rd ed.
   White Plains, NY: Addison Wesley, 2005. ISBN-13: 9780321287137

2. Other

   None

B. Optional Materials

1. Textbooks

   Greenberg, Michael D. *Advanced Engineering Mathematics*. 2nd ed.
   Upper Saddle River, NJ: Prentice Hall, 1998. ISBN-13: 9780133214314

2. Other

   None

V. POLICIES AND PROCEDURES

A. University Policies and Procedures

1. Attendance at each class or laboratory is mandatory at Oral Roberts University. Excessive absences can reduce a student's grade or deny credit for the course.
2. Students taking a late exam because of an unauthorized absence are charged a ($15) late exam fee.
3. Students and faculty at Oral Roberts University must adhere to all laws addressing the ethical use of others' materials, whether it is in the form of print, electronic, video, multimedia, or computer software. Plagiarism and other forms of cheating involve both lying and stealing and are violations of ORU's Honor Code: "I will not cheat or plagiarize; I will do my own academic work and will not inappropriately collaborate with other students on assignments." Plagiarism is usually defined as copying someone else's ideas, words, or sentence structure and submitting them as one's own. Other forms of academic dishonesty include (but are not limited to) the following:

a. Submitting another's work as one's own or colluding with someone else and submitting that work as though it were his or hers;
b. Failing to meet group assignment or project requirements while claiming to have done so;
c. Failing to cite sources used in a paper;
d. Creating results for experiments, observations, interviews, or projects that were not done;
e. Receiving or giving unauthorized help on assignments.

By submitting an assignment in any form, the student gives permission for the assignment to be checked for plagiarism, either by submitting the work for electronic verification or by other means. Penalties for any of the above infractions may result in disciplinary action including failing the assignment or failing the course or expulsion from the University, as determined by department and University guidelines.

4. Final exams cannot be given before their scheduled times. Students need to check the final exam schedule before planning return flights or other events at the end of the semester.
5. Students are to be in compliance with University, school, and departmental policies regarding Whole Person Assessment (WPA) requirements. Students should consult the WPA handbooks for requirements regarding general education and the students' majors.
   a. The penalty for not submitting electronically or for incorrectly submitting an artifact is a zero for that assignment.
   b. By submitting an assignment, the student gives permission for the assignment to be assessed electronically.

B. Department Policies and Procedures
1. Computer Resources - Each Student who uses the computer is given access to the appropriate computer resources. These limited resources and privileges are given to allow students to perform course assignments. Abuse of these privileges will result in their curtailment. Students should note that the contents of computer directories are subject to review by instructors and the computer administrative staff.
2. Late Exams - Each instructor has his or her own late-exam policy, so an instructor may decide that an exam missed because of an unexcused absence cannot be made up.
3. Unexcused Absences - Any student whose unexcused absences total 33% or more of the total number of class sessions will receive an F for the course grade.
4. Incompletes – As stated in the University catalog, incompletes are granted only for "good cause," such as extended hospitalization, long-term illness, or a death in the family. Students must petition for an incomplete using the form available in the Computing and Mathematics Department. Very few incompletes are granted.

C. Course Policies and Procedures

1. Evaluation Procedures

3 take-home exams	300 pts
1 in-class final	200 pts
Total	**500 pts**

2. Whole Person Assessment Requirements

None.

3. Other Policies and/or Procedures:

   a. **L**ate homework is not accepted.

   b. Homework must be **stapled**.

   c. **No** late exams are given. If you miss an exam, those points are added to the final exam or you receive a zero.

VI. COURSE CALENDAR

Lesson	Topic	Suggested Exercise	
Unit I			
1	Systems of Linear Equations	pp. 10-12	# 9,11,13,18,19,21,24,25,28,33,34
2	Row Echelon Form	pp. 25-26	# 1,2,5,8,9,15,19,20,23,24-28
3	Vector Equations	pp. 36-38	# 6,9,12,13,15,16,20,22,26,29,31,32
4	The Matrix Equation Ax = b	pp. 46-47	# 3,4,8,9,11,14,15,18,22,25,29,30,31,37
5	Solution Sets of Lin Systems	pp. 55-57	# 2,5,8,12,13,17,18,21,22,23,26,29,31,34
6	Linear Independence	pp. 64-66	# 2,3,8,9,14,15,19,20,22,26,27,28,31-33
7	Intro to Lin Transformations	pp. 73-75	# 2,3,7,8,9,11,14,16,17,20,21,23-26,30
8	Lin Transformation Matrix	pp. 83-85	# 2,4,6,9,12,13,15,19,21,23,24,26,28,32
9	Matrix Operations	pp. 107-109	# 3,4,6,7,10,12,15,16,17,20-22,25,26,32
10	The Inverse of a Matrix	pp. 117-119	# 3,4,6,7,9-13,16,18,22,30,32
11	Invertible Matrices	pp. 123-125	# 3,4,5,13,14,16,19,22-24,30,34-36
12	Partitioned Matrices	pp. 130-132	# 2,3,6,7,10-13,17,22
13	Matrix Factorizations	pp. 139-141	# 2,3,5,9,10,13,18
14	Review	pp. 95, 177	Review Exercises
15	**Examination I**		
Unit II			
16	Intro to Determinants	pp. 185-186	# 3-5,10-12,15,16,20,21,24,25,28,29, 33-36,39-41
17	Properties of Determinants	pp. 193-195	# 1-4,9,11,12,17-19,21,26-28,31-34,40,43
18	Cramer's Rule and Volume	pp. 204-205	# 4-6,14-16,19,20,23,25,29,31
19	Vector Spaces and Subspaces	pp. 217-219	# 2,4,7,8,10,11,13,16,17,19,23,24,26, 28,31,32
20	Null and Column Spaces	pp. 228-230	# 2,3,5,8,11,16-19,21,22,25-28,33-35
21	Bases	pp. 237-239	# 2,3,6,8,10,11,13,15,20-22,24,26
22	Coordinate Systems	pp. 248-249	# 1,3,6,7,9,12,13,15,16,18,19,21,25,28,29
23	Dimension of a Vector Space	pp. 255-256	# 3-5,8,9,11,14,19-21,23,29-32
24	Rank	pp. 263-265	# 2-4,6,9,11,12,14,16-20,23,25,28-30
25	Change of Basis	pp. 270-271	# 1-4,8,9,11-14
26	Review	pp. 206,292	Review Exercises
27	**Examination II**		
Unit III			
28	Eigenvectors and	pp. 302-304	# 1,3,5,8,9,14,16-18,20-22,25-27,30
29	Eigenvalues	pp. 311-313	# 2-4,9,10,15,16,18,21,22,25
30	The Characteristic Equation	pp. 319-320	# 1,3,5,8,11,14,17,21,22,24,25,27
31	Diagonalization	pp. 327-328	# 2-4,6,11,15,20,22,23,25,26,28
32	Linear Transformations	pp. 335-336	# 2-4,7-9,14-16,22-24,26
33	Complex Eigenvalues	pp. 376-378	# 2-4,9,10,13,15,16,19,20,22,24,28,30
34	Length and Orthogonality	pp. 386-388	# 2-4,7,8,12,14,15,17,20,23,24,26,28,29
35	Orthogonal Sets	pp. 395-396	# 2-4,7,10,11,14,17,19,21,22,24
36	Orthogonal Projections	pp. 402-403	# 2-4,7-10,15,17-20
37	The Gram-Schmidt Process	pp. 411-412	# 2-5,7-10,14,15,17,18-20,24,25
38	Least-Squares Problems	pp. 354,439	Review Exercises
39	Review		
40	**Examination III**		
41	Symmetric Matrices	pp. 448-449	# 2-4,8-10,15,17,20,24-26,28,30,31,33
42	Quadratic Forms	pp. 457-458	# 1,3,4,6,8-10,13,20-22,25,27
43	Constrained Optimization	pp. 465-466	# 1-4,7,9,11
44	Review and Synthesis		
45	Review and Synthesis		

Course Inventory for ORU's Student Learning Outcomes
MAT 312—Linear and Matrix Algebra
Summer 2017

This course contributes to the ORU student learning outcomes as indicated below:
Significant Contribution – Addresses the outcome directly and includes targeted assessment.
Moderate Contribution – Addresses the outcome directly or indirectly and includes some assessment.
Minimal Contribution – Addresses the outcome indirectly and includes little or no assessment.
No Contribution – Does not address the outcome.

The Student Learning Glossary at http://ir.oru.edu/doc/glossary.pdf defines each outcome and each of the proficiencies/capacities.

OUTCOMES & Proficiencies/Capacities	Significant Contribution	Moderate Contribution	Minimal Contribution	No Contribution
1 **Outcome #1 – Spiritually Alive** Proficiencies/Capacities				
1A Biblical knowledge			X	
1B Sensitivity to the Holy Spirit			X	
1C Evangelistic capability			X	
1D Ethical behavior		X		
2 **Outcome #2 – Intellectually Alert** Proficiencies/Capacities				
2A Critical thinking	X			
2B Information literacy	X			
2C Global & historical perspectives			X	
2D Aesthetic appreciation			X	
2E Intellectual creativity		X		
3 **Outcome #3 – Physically Disciplined** Proficiencies/Capacities				
3A Healthy lifestyle			X	
3B Physically disciplined lifestyle			X	
4 **Outcome #4 – Socially Adept** Proficiencies/Capacities				
4A Communication skills			X	
4B Interpersonal skills			X	
4C Appreciation of cultural & linguistic differences				X
4D Responsible citizenship				X
4E Leadership capacity				X