MT 330 LINEAR ALGEBRA
IES Abroad Madrid

DESCRIPTION:
Linear Algebra is the branch of mathematics that involves the study of solving systems of Linear Equations, vector spaces and linear mappings. The mastery of the subject is essential to any major related to applied and pure Mathematics and in particular to Engineering.

In this course, students will become proficient in the techniques of solving and manipulating systems. A particular focus of the course will be upon the applications of linear algebra to various Engineering fields. Among the most salient goals of the course will be an in-depth understanding of the primary theories as to why the techniques function as they do.

In particular, the course content covered during the semester is: Matrices, Determinants, Gaussian elimination, vector spaces, Linear Transformations, LU-decomposition, orthogonality, Gram-Schmidt process, inner products, eigenvalue problems, applications to differential equations and Markov processes.

CREDITS: 4 credits

CONTACT HOURS: 60 hours

LANGUAGE OF INSTRUCTION: English

PREREQUISITES: Two semesters of College Calculus/Instructor's consent.

ADDITIONAL COST: None

METHOD OF PRESENTATION:
Three hours of lecture per week (the instructor will present the theory and cover examples) and one hour of recitation per week to do exercises, examples and prepare homework. There will be two class visits related to the applications of the content of the course to Engineering: a visit to the NASA station in Robledo de Chavela, and a visit to Animation Studios in Madrid.

REQUIRED WORK AND FORM OF ASSESSMENT:
- Homework - 10%
- Class presentation - 10%
- Midterm exam - 40%
- Final exam - 40%

Course Element:

Homework
Homework will be assigned each week. No late homework will be accepted. Homework is due at the beginning of the lecture. The two lowest homework scores will be deleted for grading purposes.

Class Presentation
Presentation an application of Linear Algebra to Engineering assigned by the instructor on the third week of class.

Final Exam
The final exam is comprehensive and will include a bonus question worth 10/100 extra points that will allow the students to make up a low midterm score.

LEARNING OUTCOMES:
On successful completion of the course, students should be able to:

- Solve systems of linear equations, manipulate matrix algebra and determinants, apply row operations and elementary matrices;
- Analyze the concept and basic structure of vector spaces, give examples of vector spaces and examples of sets endowed with operations that are not vector spaces, explain the concept of dimension, apply the dimension theorem.
- Elucidate the null space, row space and column space of a matrix, apply the rank-nullity theorem.
- Give examples of linear transformations, determine whether or not a map is linear, evaluate the matrix representations of a linear transformation.
- Evaluate eigenvalues and eigenvectors, evaluate algebraic multiplicity and geometric multiplicity, diagonalize a matrix.
- Write simple proofs of statements related to the theory covered in the course.

ATTENDANCE POLICY:
As a member of our class community, you are expected to be present and on time every day. Attending class has an impact on your learning and academic success. For this reason, attendance is **mandatory for all IES Madrid classes**, including course-related excursions. Absences will only be excused in cases of documented medical or family emergencies. Any assessed work, including exams, tests, and presentations, will be rescheduled if the absence is justified; otherwise, it will be graded as 0. You are allowed a maximum of 1 unexcused absence for once-a-week courses and 2 unexcused absences for twice-a-week courses. Each additional absence will deduct 5 points from your final grade. **Accumulating 7 or more absences in twice-a-week courses, or 4 or more in once-a-week courses, may lead to a failing grade.** Students arriving more than 11 minutes after the scheduled start time will be marked as 'late.' Three 'late' arrivals will be counted as 1 absence. Any student arriving 30 minutes or more after the scheduled start time will be marked as 'absent.' For more information, please refer to the full Attendance and Punctuality Policy document.

CONTENT:

Lecture	**Content**
Lecture 1	**Linear Systems of Equations and Row Operations**
Lecture 2 (Section 1.2)	**Row-Echelon Form. Gauss-Jordan operations**
Discussion Session 1	Section 1.1, exercises 2b, 2ad, 4a, 5b, 6b, 9, 10, 11 Section 1.2, exercises 5ad, 10, 13, 15
Lecture 3 (Section 1.3)	**Matrix Arithmetic** Homework 1 is due at the beginning of the lecture
Lecture 4 (Section 1.4)	**Matrix Algebra**

Discussion Session 2	Section 1.3, exercises 6, 7, 13, 15, 16, 17 Section 1.4, exercises 3, 4, 5, 7, 10a, 18, 22, 24a, 31, 32, 33
Lecture 5 (Section 1.5)	**Elementary matrices; LU-decompositionHomework 2 is due at the beginning of the lecture**

Lecture 6 (Sections 2.1-2.2)	**Determinants. Computation by elimination and/or cofactors. Properties of determinants.**
Discussion Session 3	Section 1.5, exercises 3a, 6, 9, 10ae, 28 Section 2.1, exercises 4ac, 5, 5, 11 Section 2.2, exercises 4a, 7, 12
Lecture 7 (Section 2.3)	**Cramer's Rule. Additional topics and applications: coding messages.** Homework 3 is due at the beginning of the lecture.
Lecture 8 (Section 3.1)	**Vector Spaces, definition and examples.**
Discussion Session 4	Section 2.3, exercises 1d, 2ab, 5, 14 Section 3.1, exercises 1, 4, 5, 6
Lecture 9 (Section 3.2)	**Vector Subspaces. Span of a set of vectors** Homework 4 is due at the beginning of the lecture
Lecture 10 (Section 3.3)	**Linear independence**
Discussion Session 5	Section 3.2, exercises 1ad, 2ac, 3, 4ab, 11ab, 16a, 20 Section 3.3, exercises 1ac, 2ab, 3ab, 5, 9
Lecture 11 (Section 3.4)	**Basis and dimension** Homework 5 is due at the beginning of the lecture

Lecture 12 (Section 3.5)	**Change of Basis. Change of coordinates.**
Discussion Session 6	Section 3.4, exercises 3, 4, 5, 9, 11 Section 3.5, exercises 1a, 2a, 4, 6, 9

Lecture 13 (Section 3.6)	**Row space and column space. Review for Midterm.** Homework 6 is due at the beginning of the lecture.
Discussion Session 7	Section 3.6, exercises 1a, 2a, 4abc, 5abc
Lecture 14	
Lecture 15 (Section 4.1)	**Linear Transformations, definitions and examples. Image and Kernel.** Homework 7 is due at the beginning of the lecture.
Lecture 16 (Section 4.2)	**Matrix representation of a Linear Transformation. Application: Computer Graphics and animation.**
Discussion Session 8	Section 4.1, exercises 2, 3, 5, 7ab, 19, 20. Section 4.2, exercises 2a, 3b, 5, 10a, 11a, 14b
Lecture 17 (Section 4.3)	**Similarity. Application: Computer Graphics and animation.** Homework 8 is due at the beginning of the lecture.
Lecture 18 (Section 5.1)	**The scalar product in real vector spaces. Application: Information retrieval.**
Discussion Session 9	Section 4.3, exercises 1a, 2, 5, 7, 14 Section 5.1, exercises 1ab, 2ab, 5, 10, 17

Lecture 19 (Section 5.2)	**Orthogonal subspaces.** Homework 9 is due at the beginning of the lecture.
Lecture 20 (Section 5.3)	**Least squares problems. Application to Astronomy.**
Discussion Session 10	Section 5.2, exercises 1ac. 2, 3, 4, 12 Section 5.3, exercises 1a, 2a, 3a, 5, 14

Lecture 21 (Section 5.4)	**Inner product spaces. Cauchy-Schwarz inequality.** Homework 10 is due at the beginning of the lecture.
Lecture 22 (Section 5.5)	**Orthonormal basis and projection. Application: Signal Processing. The Discrete Fourier Transform.**
Discussion Session 11	Section 5.4, exercises 1, 2, 3, 4, 10 Section 5.5, exercises 2, 3, 4, 6, 8, 21
Lecture 23 (Sections 5.6 & 5.7)	**The Gram-Schmidt orthogonalization process and QR-factorization. Orthogonal Polynomials.** Homework 11 is due at the beginning of the lecture.
Lecture 24 (Section 6.1)	**Eigenvalues and eigenvectors. Application to Aerospace: The orientation of a space shuttle. Similar matrices (review).**
Discussion Session 12	Section 5.6, exercises 1, 2, 5, 8 Section 5.7, exercises 2, 6, 9 Section 6.1, exercises 1af, 2, 3, 4, 10
Lecture 25 (Section 6.2)	**Systems of linear differential equations. Application: Vibrations of a building.** Homework 12 is due at the beginning of the lecture

Lecture 26 (Section 6.3)	**Diagonalization. Applications: Markov Chains and web searches & page ranking.**
Discussion Session 13	Section 6.2, exercises 1ai, 2a, 3, 5a, 6 Section 6.3, exercises 1ae, 2ae, 3ae, 4a, 8a, 22, 24
Lecture 27 (Section 6.4)	**Hermitian matrices. Shur's theorem, spectral theorem. Real symmetric matrices. Normal matrices.** Homework 13 is due at the beginning of the lecture.

Lecture 28 (Section 6.5)	**The singular value decomposition. Application: Digital Image processing and information retrieval.**
Discussion Session 14	Section 6.4, exercises 1a, 2, 4ae, 5ab, 6, 17 Section 6.5, exercises 1, 2, 5
Lecture 29 (Section 6.6)	Quadratic forms. Review for final.
Discussion Session 15	Review for final exam

REQUIRED READINGS:

- ''Linear Algebra with Applications'' (8th edition-International Edition) by Steven J. Leon University of Massachusetts Dartmouth, Prentice-Hall, 2009. ISBN-13: 978-013512867-1

RECOMMENDED READINGS:

- Linear Algebra and Its Applications, 4/E David C. Lay, University of Maryland ISBN-10: 0321385179 • ISBN-13: 9780321385178 ©2012 • Pearson
- Linear Algebra and Its Applications, 4/E Gilbert Strang, Brooks Cole, ISBN 13: 978-0030105678
- Linear Algebra, 4/E, By Stephen Friedberg, Arnold J. Insel and Laurence E. Spence, ISBN-13: 978-9813026506