Linear Algebra for Computational Sciences Course Syllabus

1	**Course title**	Linear Algebra for Computational Sciences
2	**Course number**	1915101
3	**Credit hours**	3
	Contact hours (theory, practical)	3
4	**Prerequisites**	Calculus 1 (0301101)
5	**Program title**	Data Science
6	**Program code**	15
7	**Awarding institution**	The University of Jordan
8	**School**	King Abdullah II School for Information Technology
9	**Department**	Artificial Intelligence
10	**Level of course**	Undergraduate (UG)
11	**Year of study and semester (s)**	2024 - Spring (1st)
12	**Final Qualification**	BSc
13	**Other department(s) involved in teaching the course**	None
14	**Language of Instruction**	English
15	**Teaching methodology**	☒Face-to-Face ☐Blended ☐Online
16	**Electronic platform(s)**	☒Moodle ☒Microsoft Teams ☐Skype ☐Zoom ☒Others http://omar.alkadi.net/
17	**Date of production/revision**	18 February 2024

18 Course Coordinator:

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19 Other instructions:

- **Textbook:** Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares can be downloaded from here.
- **Python Language Companion to Introduction to Applied Linear Algebra:** Vectors, Matrices, and Least Squares can be downloaded from here.
- **Programming environment:** Anaconda Python distribution (version 3)

20 Course Description:

This course provides an introduction to essential linear algebra concepts with a focus on applications in data science and artificial intelligence. Topics include systems of linear equations, matrix calculus, vectors, and basic vector operations. Emphasizing problem-solving skills, the course enables students to analyze mathematical arguments effectively. Practical application is emphasized through solving computational problems in data science using the Python programming language.

21 Course aims and outcomes:

A- Aims:
On completion of this course, students should be able to:

- Understand basic concepts of linear algebra (systems of linear equations, matrix calculus, vectors and basic vector operations)
- Enhance problem-solving abilities to analyse mathematical arguments.
- Understand how linear algebra can be applied to solve computational problems in data science
- Perform linear algebra computations in Python programming language

B- Intended \ Students Learning Outcomes (ILOs \ SOs):

Label	ABET Student Learning Outcomes (SOs)
SO1	Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions.
SO2	Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.
SO5	Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.

On successfully completing the module, the students are expected to have gained good knowledge of:

Descriptor	Label	Course Intended Learning Outcomes (ILOs)
Knowledge	A	Demonstrate understanding of vector space and subspace. **[SO1]**
	B	Demonstrate understanding of linear independence, span, and basis. **[SO1]**
	F	Understanding least squares problems, data fitting and validation. **[SO1]**
Skills	C	Apply principles of linear transformations and data clustering. **[SO2]**
	D	Carry out matrix operations, including inverses, eigenvalues and eigenvectors. **[SO1]**
	E	Solve linear equations using matrix inversion. **[SO2]**
Competencies	G	Demonstrate how to solve practical linear algebra in Python programming language. **[SO2]**
	H	Demonstrate teamwork and communication skills through group work activities. **[SO5]**

22. Topic Outline and Schedule:

Week	Lecture	Topic	ILO/SO	Evaluation Methods	References
1	1.1 1.2 1.3	**Introduction to Linear Algebra**	A/SO1	Class discussions and participation	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
2	2.1 2.2 2.3	**Vectors:** addition, scalar multiplication, inner product.	A,G/SO1	Assignment	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
3	3.1 3.2 3.3	**Linear functions**: linear functions, Taylor approximation and regression model.	A/SO1	Quiz	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
4	4.1 4.2 4.3	**Norm and distance**: norm, distance, standard deviation, angle, complexity.	B/SO1	Assignment	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
5	5.1 5.2 5.3	**Clustering:** norm, distances, clustering, the *k*-means algorithm.	C,G/SO2	Class discussions and participation	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
6	6.1 6.2 6.3	**Linear independence:** linear dependence, basis, orthonormal vectors.	B/SO1	Assignment	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
7	7.1 7.2 7.3	**Matrices:** zero and identity matrices, transpose, addition, and norm, matrix-vector multiplication.	D,G/SO1	Quiz	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
8	8.1 8.2 8.3	**Matrices:** geometric transformations, selectors, incidence matrix, convolution	D,G/SO1	Assignment	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
9	9.1 9.2 9.3	**Matrices:** linear and affine functions.	E/SO1	Quiz	Moodle (http://elearning.ju.edu.jo) and subject webpage

					(http://omar.alkadi.net/2030-2)
10	10.1 10.2 10.3	**Matrices:** matrix multiplication, composition of linear functions, matrix power, QR factorization	E,G/SO2	Assignment	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
11	11.1 11.2 11.3	**Matrices:** inverse matrices, eigenvalues and eigenvectors.	D/SO1	Assignment	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
12	12.1 12.2 12.3	**Least squares:** least square problem	F/SO1	Class discussions and participation	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
13	13.1 13.2 13.3	**Least squares:** least square problem, least square data fitting.	F,G/SO1	Quiz	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
14	14.1 14.2 14.3	**Least squares:** least squares data fitting, validation, feature engineering	F/SO1	Class discussions and participation	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)
15	15.1 15.2 15.3	**Least squares:** classification, least squares classifier, multi-class classifiers	F/SO1	-	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2)

23 Evaluation Methods:

Opportunities to demonstrate achievement of the ILOs are provided through the following assessment methods and requirements:

Evaluation Activity	Mark	Topic(s)	Period (Week)	Platform
First quiz	3 marks	Vectors & Python programming	Week 3	Moodle (JUExams platform)
First, second & third assignment	2 marks	Vectors, linear functions, and norm and distance	Week 2 and 4	Moodle (elearning platform)
Fourth, fifth and sixth assignment	2 marks	Vectors, linear functions, and norm and distance	Week 5, 6 & 7	Moodle (elearning platform)

Second quiz	4 marks	Linear and affine functions	Week 7	Moodle (JUExams platform)
Midterm exam	30 marks	Vectors, linear functions, norm and distance, clustering, linear independence, and matrices	Week 8	Moodle (JUExams platform)
Sixth assignment	1 mark	Eigen values & vectors, and matrices	Week 8	Moodle (elearning platform)
Third quiz	4 marks	Norm and distance, clustering, linear independence, and matrices	Week 9	Moodle (JUExams platform)
Seventh and eighth assignment	1 mark	QR factorization & least sqaures	Week 10 and 11	Moodle (elearning platform)
Fourth quiz	3 marks	Least squares	Week 13	Moodle (JUExams platform)

24 Course Requirements (e.g.: students should have a computer, internet connection, webcam, account on a specific software/platform…etc.):

PC/laptop, Python – Anaconda distribution, Jupyter Notebook.

25 Course Policies:

A- Attendance policies: Students are responsible for attending online lectures and downloading and viewing all material covered uploaded to the LMS (http://elearning.ju.edu.jo) and the subject webpage at (http://omar.alkadi.net/2030-2).

B- Absences from exams and submitting assignments on time: It is the students' responsibility to turn in their homework assignments to their instructors by the announced due date/time. Not attending exams without a valid excuse is not accepted.

C- Health and safety procedures: Students should adhere to the University of Jordan health and safety rules and procedures

D- Honesty policy regarding cheating, plagiarism, misbehavior: For more details on University regulations please visit http://www.ju.edu.jo/rules/index.htm

E- Grading policy: 50% semester work comprising of assignments, quizzes and programming project to be submitted at the end of the semester, and 50% for final exam.

F- Available university services that support achievement in the course: http://elearning.ju.edu.jo

26 References:

A- Required book(s), assigned reading and audio-visuals:

- *Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares*, by Stephen Boyd and Lieven Vandenberghe, (Cambridge University Press, 3rd edition)

B- Recommended books, materials and media:

- *Introduction to Linear Algebra*, by Gilbert Strang, (Wellesley Cambridge Press, 5th Ed).
- *Contemporary Linear Algebra*, by Anton and Busby, (Wiley.
- *Elementary Linear Algebra; applications version*, by Anton, H., Rorres, C., (Wiley, 12th Ed).
- *Linear Algebra and its Applications*, by Lay, David C., (Addison Wesley, 2nd Ed).
- *Linear Algebra with Applications*, by Leon, Steven J., (Prentice Hall, 6th Ed).
- *Applied Linear Algebra*, by Noble, B. and Daniel, J., (Prentice-Hall, 3rd Ed).

27 Additional information:

For additional information, student can refer to the lecturers' website at http://omar.alkadi.net/teaching