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| **1** | **Course title** | Linear Algebra for Data Science and Artificial Intelligence |
| **2** | **Course number** | 1914101 |
| **3** | **Credit hours** | 3 |
| | **Contact hours (theory, practical)** | 3 |
| **4** | **Prerequisites** | Discrete Mathematics (1901101) |
| **5** | **Program title** | Data Science |
| **6** | **Program code** | 04 |
| **7** | **Awarding institution** | The University of Jordan |
| **8** | **School** | King Abdullah II School for Information Technology |
| **9** | **Department** | Information Technology |
| **10** | **Level of course** | Undergraduate (UG) |
| **11** | **Year of study and semester (s)** | 2021 - Spring |
| **12** | **Final Qualification** | BSc |
| **13** | **Other department(s) involved in teaching the course** | None |
| **14** | **Language of Instruction** | English |
| **15** | **Teaching methodology** | ☐Blended ☒Online |
| **16** | **Electronic platform(s)** | ☒Moodle ☒Microsoft Teams ☐Skype ☒Zoom ☒Others http://omar.alkadi.net/ |
| **17** | **Date of production/revision** | 18 February 2021 |

**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.

**20 Course Description:**

The aim of this course is to provide an introduction to vectors, matrices, and least square methods, all basic topics in linear algebra, in the context of data science and artificial intelligence.

**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 Learning Outcomes (ILOs):
Upon successful completion of this course, students will be able to:

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

| No. | **Course Intended Learning Outcomes (CILOs)** |
|---|---|
| | **Knowledge** |
| A | Solve linear equations using Gaussian elimination and matrix inversion. |
| B | Carry out matrix operations, including inverses and determinants. |
| C | Demonstrate understanding of vector space and subspace. |
| D | Demonstrate understanding of linear independence, span, and basis. |
| E | Apply principles of matrix algebra to linear transformations. |
| F | Determine eigenvalues and eigenvectors and solve eigenvalue problems. |
| | **Professional Skill** |
| G | Demonstrate how to solve practical linear algebra in Python programming language |
| H | Demonstrate teamwork and communication skills through group work activities |

**22. Topic Outline and Schedule:**

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

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|---|---|---|---|---|---|
| | 9.2<br>9.3 | **Matrices:** linear and affine functions. | Synchronous<br>Asynchronous | | Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2) |
| 10 | 10.1<br>10.2<br>10.3 | **Matrices:** matrix multiplication, composition of linear functions, matrix power, QR factorization | Synchronous<br>Synchronous<br>Asynchronous | Online class discussion and participation | Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2) |
| 11 | 11.1<br>11.2<br>11.3 | **Matrices:** inverse matrices, eigenvalues and eigenvectors. | Synchronous<br>Synchronous<br>Asynchronous | Quiz | Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2) |
| 12 | 12.1<br>12.2<br>12.3 | **Least squares:** least square problem | Synchronous<br>Synchronous<br>Asynchronous | Online class discussion and participation | Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2) |
| 13 | 13.1<br>13.2<br>13.3 | **Least squares:** least square problem, least square data fitting. | Synchronous<br>Synchronous<br>Asynchronous | Online class discussion and participation | Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2) |
| 14 | 14.1<br>14.2<br>14.3 | **Least squares:** least squares data fitting, validation, feature engineering | Asynchronous<br>Asynchronous<br>Asynchronous | Online class discussion and participation | Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2) |
| 15 | 15.1<br>15.2<br>15.3 | **Least squares:** classification, least squares classifier, multi-class classifiers | Synchronous<br>Synchronous<br>Asynchronous | - | Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2030-2) |

- Teaching methods include: Synchronous lecturing/meeting; Asynchronous lecturing/meeting
- Evaluation methods include: Homework, Quiz, Exam, pre-lab quiz…etc.

**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 | 4 marks | Vectors & linear functions | Week 3 | Moodle |

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| First and second assignment | 2 marks | Vectors, linear functions, and norm and distance | Week 2 and 4 | Google Classroom |
| Midterm exam | 30 marks | Vectors, linear functions, norm and distance, clustering, linear independence, and matrices | Week 7 | Moodle |
| Third and fourth assignment | 2 marks | linear independence, and matrices | Week 6 and 8 | Google Classroom |
| Hands-on programming quiz | 3 marks | Vectors, linear functions, norm and distance, clustering, linear independence, and matrices | Week 11 | Moodle |
| Third quiz | 4 marks | Least squares | Week 13 | Moodle |

**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