DAMA501 Module Outline

1. GENERAL

SCHOOL	School of Science and Technology		
PROGRAMME	Data Science and Machine Learning		
LEVEL OF STUDIES	Level 7 of the Hellenic and European Qualifications Framework		
MODULE CODE	DAMA501	**SEMESTER**	1/3
MODULE TITLE	Linear Algebra and Calculus		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**HOURS**	**CREDITS**
Weekly workload: 32-33 hours x 13 weeks		420	15 ECTS
MODULE TYPE *Compulsory/Elective/ Mandatory Optional*	Compulsory/Elective		
PREREQUISITE MODULES	None		
LANGUAGE OF INSTRUCTION and EXAMINATIONS	English		
IS THE MODULE OFFERED TO ERASMUS STUDENTS	Yes		
MODULE WEBSITE (URL)	The Module has a dedicated space in HOU's digital learning platform (http://courses.eap.gr, http://study.eap.gr), which students and tutors can access using their credentials.		

2. LEARNING OUTCOMES

Learning outcomes

The learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the Module are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

Knowledge:

Upon successful completion of the Module, students will be able to:

- Recognize that a basic mathematical pillar for machine learning is linear algebra and vector calculus.
- Summarize basic notions of vector spaces.
- Outline the concepts of norm of a vector and of inner product between two vectors.
- Explain what an orthonormal basis is in a vector space and describe the orthogonal complement of a subspace of the vector space.
- Recall the definition of the trace and the determinant of a matrix.
- Explain the concepts of eigenvalues and eigenvectors of square matrices.
- Outline the concept of the gradient of a function of many variables and describe its geometric significance.
- Summarize the gradient of matrices and its geometric significance.
- Summarize the concept of backpropagation.

Skills:

Upon successful completion of the Module, students will be able to:

- Carry out core vector–matrix operations—addition, multiplication, transposition, inversion, trace and determinant—both analytically and with computational tools such as SageMath/NumPy.
- Compute and interpret norms, inner products and distances in -$\mathbb{R}^n$ vector spaces, using these measures to assess similarity and orthogonality in data representations.
- Solve systems of linear equations and perform matrix factorizations to support dimensionality-reduction, stability analysis and numerical optimisation workflows.
- Evaluate eigenvalues and eigenvectors.
- Derive and implement back-propagation updates for simple feed-forward neural networks, translating analytical derivatives into executable code.
- Apply change-of-basis and coordinate-transformation techniques (orthogonal/orthonormal, diagonalisation) to simplify problem formulations and reveal latent structure in datasets.
- Leverage computational mathematics environments (e.g., SageMath) to experiment with vector fields, level-set visualisations and optimisation trajectories, validating analytical results numerically.

Competences:

Upon successful completion of the Module, students will be able to:

- Apply core mathematical tools (e.g., linear algebra, calculus) to analyze and interpret machine learning models.
- Select and apply appropriate matrix decomposition techniques in practical data scenarios.
- Use vector space concepts (orthogonality, inner products, basis changes) in interpreting and simplifying machine learning problems.
- Evaluate the significance of gradients and backpropagation in optimizing learning algorithms.
- Use computational tools (SageMath) autonomously to explore mathematical properties relevant to machine learning.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the Module aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology
Adapting to new situations
Decision-making
Working independently
Team work
Working in an international environment
Working in an interdisciplinary environment
Production of new research ideas
Project planning and management
Respect for difference and multiculturalism
Respect for the natural environment
Showing social, professional and ethical responsibility and sensitivity to gender issues
Criticism and self-criticism
Production of free, creative and inductive thinking

The general skills that the students will acquire are:

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Adapting to new situations
- Decision-making
- Working independently
- Team work
- Project planning and management
- Showing social, professional and ethical responsibility and sensitivity to gender issues
- Production of free, creative and inductive thinking

3. SYLLABUS

Purpose of Module

The students will learn the basic mathematical tools necessary for Machine Learning (ML). These include basic concepts from linear algebra such as vectors, matrices and operations with vectors and matrices. From calculus, students will be exposed to functions of many real variables and the basic concept of the gradient and directional derivative to be applied in backpropagation ML algorithms. Overall, a student without prior knowledge of these mathematical areas will be able to form a background to understand ML techniques while students with prior mathematical knowledge will be able to go much deeper in application of mathematics in ML. The mathematical study will be supplemented by computational software that will enable both analytical and numerical evaluations.

The key subjects of the module are “Linear Algebra” and “Calculus”.

4. TEACHING and LEARNING METHODS - EVALUATION

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<td>**DELIVERY**
Face-to-face, Distance learning, etc.</td>
<td>- Distance teaching and learning with three (3) Group Counseling Meetings (GCMs) of 4-hour duration during the academic semester on weekends.
- Personal communication and feedback (advisory role of Adjunct Faculty).</td>
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<td>**USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY**
Use of ICT in teaching, laboratory education, communication with students</td>
<td>During GCMs and teaching the following are used:
- Remote meetings tools (webex, Teams),
- Presentation software (PowerPoint, educational video - animations etc.),
- Specialized software/databases for the subjects under study.
In addition, students use office automation tools, web browsers and e-reader for digital books.
Communication with the students is supported by:
- The digital platform of HOU ((https://courses.eap.gr/login/index.php / https://study.eap.gr/login/index.php) (course information, educational material posts, announcements, messages, examination results, user groups, discussion forums etc.).
- e-mail and messaging.</td>
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<td>**TEACHING METHODS**
The manner and methods of teaching are described in detail.
Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.
The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</td>
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<table>
<tr><th>*Activity*</th><th>*Semester Workload*</th></tr>
<tr><td>3 GCMs (x 4 hours)</td><td>12</td></tr>
<tr><td>3 Semester Assignments (x 27 hours)</td><td>81</td></tr>
<tr><td>Individual Study time (25 hours x 13 weeks)</td><td>325</td></tr>
<tr><td>Final examination</td><td>3</td></tr>
<tr><td>***Total Workload***</td><td>**421**</td></tr>
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<td>**STUDENT PERFORMANCE EVALUATION**
Description of the evaluation procedure
Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other
Specifically-defined evaluation criteria are given, and if and where they are accessible to students.</td>
<td>**Students’ evaluation – Grade assessment of a Module:**
a. Three (3) Semester Assignments (A) which contribute equally to the final grade with a value of 10% each.

The scoring of assignments is activated only if the student succeeds in an overall score equal to or above the base (≥50%) in the final or repeat exams.

b. Final or repeat exams (E) contribute to the final grade of the module by 70%.

The Final Grade of the module is calculated as follows (with 10 being the maximum Grade):

Final Grade = (A1 x 10%) + (A2 x 10%) + (A3 x 10%) + (E x 70%)

Language of evaluation: English</td>
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5. INDICATIVE BIBLIOGRAPHY

- Recommended bibliography:

- Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong. Mathematics for Machine Learning. Cambridge University Press, 2020
- Paul Zimmermann, Alexandre Casamayou, Nathann Cohen, Guillaume Connan, Thierry Dumont, Laurent Fousse, François Maltey, Matthias Meulien, Marc Mezzarobba, Clément Pernet, Nicolas M. Thiéry, Erik Bray, John Cremona, Marcelo Forets, Alexandru Ghitza, Hugh Thomas. Computational Mathematics with SageMath. SIAM, 2018

Additional digital (and multimedia) material will be made available online.