

COURSE OUTLINE

(1) GENERAL

SCHOOL	Engineering		
ACADEMIC UNIT	Department of Financial & Management Engineering		
LEVEL OF STUDIES	Postgraduate		
COURSE CODE	I.2	SEMESTER	A
COURSE TITLE	Machine Learning for Industrial Transformation and Innovation		
INDEPENDENT TEACHING ACTIVITIES <i>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, state the weekly teaching hours and the total credits</i>		WEEKLY TEACHING HOURS	CREDITS
Credits are awarded for the whole of the course		3	6
<i>Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail in section (4).</i>			
COURSE TYPE <i>general background, special background, specialization, general education, skills development</i>	General background		
PREREQUISITE COURSES	No		
LANGUAGE OF INSTRUCTION AND OF ASSESSMENT	English		
MODE OF TEACHING <i>in-person (%)</i> <i>synchronous distance learning (%)</i> <i>asynchronous distance learning (%)</i> <i>(In the case of synchronous distance learning, the total weekly duration of teaching is recorded)</i>	Synchronous distance learning (95%) Asynchronous distance learning (5%)		
AVAILABILITY TO ERASMUS STUDENTS	No		
COURSE WEBSITE (URL)	https://aisbd.aegean.gr/en/c/machine-learning-industrial-transformation-and-innovation		

(2) LEARNING OUTCOMES

Learning Outcomes <i>The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.</i> <i>Consult Appendix A</i> • 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 • Brief Guide for drafting Learning Outcomes
Upon successful completion of the course, students will be able to understand the role of Artificial Intelligence (AI) and Machine Learning (ML) in contemporary Intelligent Decision Support Systems and describe how these systems contribute to data-driven, sustainable and adaptive decision-making in Industry 4.0 environments. In particular, students will learn how to 1. Formulate and quantitatively model industrial and business decision-making problems by defining objectives, alternative courses of action, constraints, uncertainty factors and data

needs. 2. Distinguish between classical Operations Research (OR) methods and AI/ML-based decision-support approaches, identifying their respective assumptions, strengths, limitations and areas of complementarity. 3. Integrate forecasting models with optimization methods to support decisions under demand, price or operational uncertainty. 4. Identify optimal courses of action under multiple and potentially conflicting criteria using multi-objective optimization techniques. 5. Design the architecture of an Intelligent Decision Support System, including data inputs, analytical models, optimization modules, uncertainty treatment and presentation of results. 6. Apply supervised, unsupervised and reinforcement learning techniques to a range of decision-making problems involving classification, prediction, anomaly detection, resource allocation, scheduling and routing. 7. Develop and present a capstone project that integrates uncertainty analysis with machine learning and optimization to address a realistic industrial decision-making situation.																			
General Competences <i>Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and are stated below), at which of the following does the course aim?</i> <table> <tr> <td><i>Search, analysis and synthesis of data and information, with the use of the necessary technology</i></td><td><i>Project planning and management</i></td></tr> <tr> <td><i>Adaptability to new situations</i></td><td><i>Respect for difference and multiculturalism</i></td></tr> <tr> <td><i>Decision-making</i></td><td><i>Respect for the natural environment</i></td></tr> <tr> <td><i>Working independently</i></td><td><i>Showing social, professional and ethical responsibility and sensitivity to gender issues</i></td></tr> <tr> <td><i>Team work</i></td><td><i>Criticism and self-criticism</i></td></tr> <tr> <td><i>Working in an international environment</i></td><td><i>Production of free, creative and inductive thinking</i></td></tr> <tr> <td><i>Working in an interdisciplinary environment</i></td><td><i>.....</i></td></tr> <tr> <td><i>Production of new research ideas</i></td><td><i>Other...</i></td></tr> <tr> <td></td><td><i>.....</i></td></tr> </table>		<i>Search, analysis and synthesis of data and information, with the use of the necessary technology</i>	<i>Project planning and management</i>	<i>Adaptability to new situations</i>	<i>Respect for difference and multiculturalism</i>	<i>Decision-making</i>	<i>Respect for the natural environment</i>	<i>Working independently</i>	<i>Showing social, professional and ethical responsibility and sensitivity to gender issues</i>	<i>Team work</i>	<i>Criticism and self-criticism</i>	<i>Working in an international environment</i>	<i>Production of free, creative and inductive thinking</i>	<i>Working in an interdisciplinary environment</i>	<i>.....</i>	<i>Production of new research ideas</i>	<i>Other...</i>		<i>.....</i>
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The course aims at developing the following general competences: • Search, analysis and synthesis of data and information, with the use of the necessary technology. • Adaptability to new situations. • Decision-making. • Working independently. • Team work. • Working in an interdisciplinary environment. • Production of new research ideas. • Project planning and management. • Respect for the natural environment (especially through applications in sustainable resource management, resilient planning and energy systems). • Production of free, creative and inductive thinking.																			

(3) COURSE SYLLABUS

Decision Analysis and Intelligent Decision Support Systems

Decision analysis; objectives, alternatives, constraints and decision criteria; single-objective and multi-objective decision-making; classical versus intelligent decision-support systems; AI and ML in Industry 4.0 decision-making pipelines; overview of supervised, unsupervised and reinforcement learning frameworks.

Decision Support for Classification and Anomaly Detection Problems

Classification as a decision-support task; rule engines; expert systems; tree-inductive learning; decision rules, model transparency and explainable artificial intelligence (XAI); anomaly and outlier detection; statistical process control; unsupervised ML techniques; applications in fault diagnosis, process monitoring, operational risk screening and fraud detection.

Optimal Decision-Making under Uncertainty

Types of uncertainty/risk; econometric and ML forecasting methods; probabilistic modelling and scenario generation; asymmetric cost functions and risk metrics; stochastic programming and optimization metaheuristics; applications in sustainable procurement, inventory planning and energy trading.

Planning and Resource Allocation Decision Support

Resource allocation under constraints; deterministic and stochastic formulations; nonlinear and integer programming; computational intelligence methods for allocation decisions; multi-criteria decision-making; pareto optimality and the efficient frontier; applications in resilient production planning, parking-space allocation and capacity planning.

Dynamic Operations Planning and Control

Scheduling and routing problems in business and industrial operations; static and dynamic formulations; sequential decision making; combinatorial optimization and dynamic programming; evolutionary algorithms and reinforcement learning for adaptive planning and control; applications in manufacturing scheduling, logistics and delivery planning.

Capstone Project: Building an Intelligent Decision-Support System

End-to-end design of an Intelligent Decision Support System; problem definition; data requirements; selection of ML and optimization methods; uncertainty modelling; algorithmic workflow; visualization and presentation of decision recommendations.

(4) TEACHING AND LEARNING METHODS - ASSESSMENT

MODE OF TEACHING <i>Face-to-face, distance learning, etc.</i>	Distance learning
MODE AND FREQUENCY OF COMMUNICATION WITH THE STUDENTS	• Modes of communication: teleconference, email correspondence, written feedback reports. • Frequency of communication: weekly
ENSURING THE MODE OF COMMUNICATION AMONG STUDENTS <i>Team assignments and discussions, collaborative learning platforms with the use of AI, video conference, QA sessions, κ.α.</i>	Student communication and collaboration will be supported through: • team assignments • case-study discussions • online discussion forums • teleconference meetings
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY <i>Use of ICT in teaching, in laboratory training, in the communication with students</i>	ICT will be extensively used in lecturing, laboratory training, communication and assessment. Students will employ a variety of computational tools for data analysis, machine learning, optimization modelling, visualization and the development of intelligent decision-support prototypes. The institutional e-learning platform will support the distribution of material, announcements, assignment submission, feedback and asynchronous communication.
TECHNOLOGICAL EQUIPMENT REQUIREMENTS	Students are expected to have access to a personal computer, a stable internet connection, the institutional e-learning platform and a computational environment suitable for data analysis, machine learning, and optimization, such as Excel, Weka, Python and Matlab with the associated scientific libraries.

PLAGIARISM POLICY/ PLAGIARISM DETECTION TOOLS	All student projects and submitted work must comply with the University of the Aegean's Code of Ethical Conduct and Good Practice. Students are required to properly acknowledge all sources, datasets, software libraries, AI tools and external material used in their assignments and projects. Written assignments will be checked with plagiarism detection tools, such as Turnitin. Any issues related to plagiarism, unauthorised collaboration or misrepresentation of authorship will be addressed according to the institutions' regulations.																
ARTIFICIAL INTELLIGENCE POLICY (1) The use of Artificial Intelligence is prohibited in all circumstances (2) The use of Artificial Intelligence is allowed only with the permission of the instructor (3) The use of Artificial Intelligence is allowed only with an explicit reference to the literature (4) Students are free to use Artificial Intelligence	The use of Artificial Intelligence is allowed only with an explicit reference to the literature																
ORGANISATION OF TEACHING The mode and methods of teaching are described in detail. Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, work placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artworks, etc. The student's study hours for each learning activity are stated, as well as the hours of independent study, according to the principles of the ECTS.	<table border="1"> <thead> <tr> <th>Activity</th><th>Semester workload (hours)</th></tr> </thead> <tbody> <tr> <td>Lectures</td><td>15</td></tr> <tr> <td>Laboratory sessions and case studies</td><td>15</td></tr> <tr> <td>Weekly online quizzes</td><td>20</td></tr> <tr> <td>Individual study</td><td>45</td></tr> <tr> <td>Capstone project</td><td>50</td></tr> <tr> <td>Final exam</td><td>5</td></tr> <tr> <td>Course total</td><td>150</td></tr> </tbody> </table>	Activity	Semester workload (hours)	Lectures	15	Laboratory sessions and case studies	15	Weekly online quizzes	20	Individual study	45	Capstone project	50	Final exam	5	Course total	150
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STUDENT ASSESSMENT Description of the assessment method Language of assessment, methods of assessment, formative or summative assessment, multiple choice questions test, short answer questions, essay questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory assignment, clinical examination of patient, art interpretation, other Specifically-defined evaluation criteria are given, and if and where they are accessible to students.	<table border="1"> <thead> <tr> <th>Student assessment</th><th>Weight (%)</th></tr> </thead> <tbody> <tr> <td>Final exam (short answer questions, numerical problem solving)</td><td>40%</td></tr> <tr> <td>Capstone project</td><td>60%</td></tr> <tr> <td>Total</td><td>100%</td></tr> </tbody> </table> To successfully complete the module, students must obtain a passing grade (greater than or equal to 50%) in the final exam. The language of assessment is English.	Student assessment	Weight (%)	Final exam (short answer questions, numerical problem solving)	40%	Capstone project	60%	Total	100%								
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(5) RECOMMENDED BIBLIOGRAPHY

- Suggested bibliography:

- Russell, S., & Norvig, P. (2020). Artificial Intelligence: A Modern Approach (4th ed.). Pearson.
- Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer.
- Hastie, T., Tibshirani, R., & Friedman, J. (2009). The Elements of Statistical Learning: Data Mining, Inference, and Prediction (2nd ed.). Springer.
- Murphy, K. P. (2022). Probabilistic Machine Learning: An Introduction. MIT Press. (Η το παλιότερο: Murphy, K. P. (2012). Machine Learning: A Probabilistic Perspective. MIT Press.
- Sutton, R. S., & Barto, A. G. (2018). Reinforcement Learning: An Introduction (2nd ed.). MIT Press .
- Hillier, F. S., & Lieberman, G. J. (2020). Introduction to Operations Research (11th ed.). McGraw-Hill.
- Boyd, S., & Vandenberghe, L. (2004). Convex Optimization. Cambridge University Press.
- Bertsekas, D. P. (2017). Dynamic Programming and Optimal Control (4th ed.). Athena Scientific.
- Sharda, R., Delen, D., & Turban, E. (2020). Analytics, Data Science, and Artificial Intelligence: Systems for Decision Support (11th ed.). Pearson.
- Keeney, R. L., & Raiffa, H. (1993). Decisions with Multiple Objectives: Preferences and Value Tradeoffs. Cambridge University Press.

- Related academic journals:

- Decision Support Systems
- European Journal of Operational Research
- Computers & Operations Research
- Omega
- Expert Systems with Applications
- IEEE Transactions on Systems, Man, and Cybernetics: Systems
- International Journal of Production Economics
- International Journal of Production Research
- Journal of Manufacturing Systems
- Applied Energy
- Energy Economics
- Renewable Energy
- International Journal of Forecasting
- Journal of Time Series Analysis
- Transportation Research Part E: Logistics and Transportation Review