ANNEX 2 – COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">Mechatronics in Vehicle Engineering</td></tr>
<tr><td>Course Code</td><td colspan="5">AU412</td></tr>
<tr><td>Course Type</td><td colspan="5">Compulsory</td></tr>
<tr><td>Level</td><td colspan="5">BSc (Level 1)</td></tr>
<tr><td>Year / Semester</td><td colspan="5">4^{th} / Spring</td></tr>
<tr><td>Teacher's Name</td><td colspan="5">Evagoras Xydas</td></tr>
<tr><td>ECTS</td><td>6</td><td>Lectures / week</td><td>3</td><td>Laboratories/week</td><td>1</td></tr>
<tr><td>Course Purpose</td><td colspan="5">The aim of the course is to provide students with the knowledge and understanding of the principles that are needed for synthesis and analysis of mechatronic systems, with some focus in the automotive sector. It enables the development of the required skills in combining physical systems, signal processing, digital and electronic systems with modern controllers and microprocessors and projection of this knowledge to the context of the vehicle systems' integration through digital protocols.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">On completion of the course, students will be able to:
1. Explain the architecture of mechatronic systems.
2. Assemble, program, analyze and specify sensor and actuator systems.
2. Analyze and specify modern Data Acquisition (DAQ) systems.
3. Convert controller functions and plant transfer functions from the Laplace's transforms to z-transforms, to the discrete domain.
5. Design simple controllers to regulate the behaviour (e.g., motor speed) of a mechatronic system.
6. Explain the operation of CANBUS and integration of the Vehicle Mechatronic Systems within the CANBUS communication protocol. Understand CANBUS message structure and CANBUS operations.
7. Assemble and program ADC and DAC (Analogue to Digital and Digital to Analogue) measurement and control systems using Tinkercad software and Arduino Hardware and sensors/actuators. Connect theory of digital systems to practice by visualizing actual ADC and DAC measurements in Decimal and Binary forms.</td></tr>
<tr><td>Prerequisites</td><td colspan="2">AU206, AU411, ME310</td><td colspan="2">Corequisites</td><td></td></tr>
<tr><td>Course Content</td><td colspan="5">Mechatronic Systems: Definition of mechatronics. Applications of Mechatronic Systems. Components of mechatronic systems. Primary elements and functions of a mechatronic system. Integration of mechatronic systems. Evolution of automotive mechatronics.

Sensors and actuators: basic principles of sensor and transduction. Measurement characteristics. Sensor specifications. Position sensors,</td></tr>
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	force and pressure sensors, flow sensors, temperature sensors, proximity sensors, etc. Types of actuators. Stepper-motors, solenoids, servo-motors, Hydraulic and Pneumatic Actuators. **Analogue to Digital and Digital to Analogue conversion:** Decimal, binary hexadecimal systems and conversions. Analogue versus digital signals. Introduction to Data Acquisition Systems (DAQ). Interfacing of sensors and actuators to DAQ. • Types-Synchronous, Asynchronous, Serial, Parallel. • Bit width, Sampling theorem, • Aliasing, • Sample and hold circuit, • Sampling frequency; • Interfacing of Sensors / Actuators to Data Acquisition system; • Quantization and digitization. • 4-bit Successive Approximation type ADC; • 4-bit R-2R type DAC; • Current and Voltage Amplifier. **Communication systems and microprocessors:** computer organization (CPU, ALU/CU/Registers, address bus, data bus, set/reset bus, polling & interrupt, etc.). Introduction to CANBUS. Elements of CANBUS. Systems integration and interfacing using CANBUS. Connection, transmission, message format in CANBUS networks. **Discrete control systems:** simple introduction to z-transforms for modelling of mechatronic systems and conversion from the continuous to the discrete domain. Zero-order-hold, Euler Backward Differentiation Formula, Euler Forward Differentiation Formula. Jury Criterion. Discrete model of a PID controller. Discrete PID controller inside a code. **CANBUS training using the MATRIX E-blocks 2 solution:** Introduction to the system, description of elements and connections. Start-up scan**:** demonstrate an initial start-up scan that checks that the system components are all connected and working, and how this can help in automotive diagnostics. CAN monitor: monitor the messages and data being sent on the CAN bus. Display the Node and function, the Message ID and the Data. Worked example / breaking: Create a CAN network that turns on the brake light when the brake pedal is pressed. **Tinkercad and Arduino:** Introduction to Arduino. Introduction to tinkercad. Transfer of code from tinkercad to Arduino. All class experiments are done using first tinkercad, then Arduino. Analogue and digital write: timed blinking and intensity control of LED. Analogue and digital read: switch input and potentiometer input. Control of stepper motor: single coil excitation, half-step and full-step drive. Simulation of micro-stepping using four LEDs. Microstepping control of stepper motor.
Teaching Methodology	Students are taught through lectures (3 hours per week) in classrooms or lectures theatres, and in the computer labs (1 hour per week) where the Arduino sets and the MATRIX E-blocks 2 CANBUS training programs are utilized for demonstration and class assignments. The students also work on in group projects on their own to complete their Arduino tasks.

	Auditory exercises, where examples regarding matter represented at the lectures, are solved and further, questions related to particular open-ended topic issues are compiled by the students and answered, during the lecture or assigned as homework. Topic notes are compiled by students, during the lecture which serve to cover the main issues under consideration and can also be downloaded from the e-learning platform or the lecturer's webpage. Students are also advised to use the subject's textbook or reference books for further reading and practice in solving related exercises. Tutorial problems are also submitted as homework and these are solved during lectures or privately during lecturer's office hours. Furthermore, the theory is connected to practice using the series of class assignments and home-assignments in group-work. The students use the provided Arduino sets as well as a CANBUS training system in hands-on understanding of ADC and DAC, CANBUS elements and message format, etc. Students are prepared for final exam, by revision on the matter taught, problem solving and concept testing and are also trained to be able to deal with time constraints and revision timetable.
Bibliography	**(a) Textbooks:** • D.G. Alciatore and M.B. Histand, ***Introduction to Mechatronics and Measurement Systems***, McGraw-Hill, 4th Edition, 2012. • Neal S. Widmer, Greg Moss & Ronald J. Tocci, **Digital Systems, Global Edition, Pearson,** 12th Edition • Konrad Reif, ***Automotive Mechatronics: Automotive Networking, Driving Stability Systems, Electronics***, Springer Vieweg, 2015. **(b) References:** • **E-Blocks 2, CANBUS Communication, CANBUS Training notes**, Matrix Technology Solutions Limited, 2018 • Arduino tutorials, https://docs.arduino.cc/tutorials/ Accessed: 23 June 2022; • Autodesk TinkerCAD, https://www.tinkercad.com/ Accessed: 23 June 2022
Assessment	The final assessment of the students is formative and summative and is assured to comply with the subject's expected learning outcomes and the quality of the course. The students are assessed via continuous assessment throughout the duration of the Semester, as well as with a laboratory and project work, which forms the Coursework grade and the final written exam. The coursework and the final exam grades are weighted 40% and 60%, respectively, and compose the final grade of the course. Assignments range from simple class assignments and homeworks. An important part of the continuous assessment is the design, development, programming and presentation of a mechatronic system using Arduino hardware.

	The assessment weight, date and time of each type of continuous assessment is being set at the beginning of the semester via the course outline. An indicative weighted continuous assessment of the course is shown below: • Assignments (class and home) 15% • Mid-Term written exam 10% • Project Work 15% • Final Exam 60% Students are prepared for final exam, by revision on the matter taught, problem solving and concept testing and are also trained to be able to deal with time constrains and revision timetable.
Language	English