ANNEX 2 – COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">Electric and Alternative Vehicle Propulsion Systems</td></tr>
<tr><td>Course Code</td><td colspan="5">AU307</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">3rd (Spring)</td></tr>
<tr><td>Teacher’s Name</td><td colspan="5">Evagoras Xydas, George Karagiorgis, Xenakis Vouvakos</td></tr>
<tr><td>ECTS</td><td>6</td><td>Lectures / week</td><td>2</td><td>Laboratories/week</td><td>2</td></tr>
<tr><td>Course Purpose</td><td colspan="5">The aim of the course is to familiarize students with the basic concepts and principles of electric and alternative vehicle propulsion systems. Different drive systems such as unconventional types of combustion engines using alternative fuels (liquified petroleum gas, compressed natural gas, hydrogen), gas turbines, fuel cells as well as electric and hybrid electric propulsion systems are analyzed. Control strategies based on various drive concepts are introduced and different components such as electric motors, hydraulic machines, batteries and flywheels are analyzed.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">By the end of the course, students must be able to:
1. Identify and describe alternative vehicle propulsion systems (LPG, CNG, Hydrogen).
2. Understand the components and characteristics of electric and hybrid electric vehicle propulsion systems.
3. Synthesize and analyse the differential equations that describe the interaction and transfer of power between electric and ICE components inside the hybrid vehicle.
4. Synthesize and analyse the differential equations that describe the dynamics and the power generation of electric vehicles.
5. Recognise and describe the application of fuel cells in vehicles and its advantages of high energy efficiency, much lower emissions and longer driving range.
6. Understand the theory, operation, construction, design features, unique characteristics and servicing protocol of electric machines currently being used in Electric and Hybrid Electric vehicle propulsion systems (including DC, AC induction, permanent magnet
7. Describe and compare different design approaches relating to the operation, construction, architecture and servicing protocol of power inverters, DC converters and vehicle accessory systems used in Electric Vehicle Propulsion
8. Explain and compare alternative vehicle propulsion technologies that may be utilised in future propulsion systems
9. Design and model electric propulsion systems using Matlab/Simulink simulation.</td></tr>
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<tr><td>Prerequisites</td><td>ME200, AU203</td><td>Corequisites</td><td>AU303</td></tr>
<tr><td>Course Content</td><td colspan="3">
Alternative Fuels: Compressed Natural Gas (CNG), Liquified Petroleum Gas (LPG), Methanol, Ethanol, Hydrogen, Vegetable Oils, Dimethyether and Synthetic Fuels.
Electric Propulsion Systems: Electric Mobility, Electromotors, Accumulators of electrical energy, batteries, fuel cells. Categories and main characteristics of electric propulsion vehicles.
Electric Vehicle Technology: Electric and Hybrid Electric vehicle layouts, Hybrid systems, control units, power electronics, charging points, isolators, inverter, battery management controller, ignition/key-on control, relays, driver display panel/interface. Regulations and Standards developed to harmonize Electric Vehicle Systems (ECE-R100).
Control of Electric and Hybrid Propulsion Systems/Vehicles: basic models of electric vehicles and their transmission, electric motors and their models, elements of control systems for different types of electric motors, controller specification and design for electric propulsion systems. Control and energy optimization of hybrid (ICE + Electric) propulsion systems.
Introduction to Battery Technology: Battery theory and construction, chemical energy to electrical energy, safety precautions, battery ratings, battery types (Flooded Lead/Acid, AGM, Nickel-Metal Hydride, Lithium-Ion Technologies), comparison between battery technologies, testing and servicing, cylindrical vs prismatic design and environmental concerns.
Fuel Cells: Fuel Cell technologies and system characteristics, Operating principles, fuel and oxidant consumption, proton exchange membrance, alkaline, phosphoric acid, molden carbonate, solid oxide and direct methanol fuel cells. Hydrogen storage. Fuel Cell Hybrid electric drivetrain design.
Combinations of Propulsion Systems, Energy Sources, Converters and Storage: Propulsion by motor with energy conversion on board via a thermal engine (piston, Wankel, Stirling engine, gas turbine), or fuel cell, using liquid or gaseous fuel in combination with electric energy storage in a battery. Propulsion by a motor with storage of electric energy in a battery. Propulsion by a combination of internal combustion engine using liquid or gaseous fuel and one or more motors with energy stored in batteries. Plug-in Hybrid propulsion.
Laboratory Exercises

Installation of LPG and CNG system in an indirect-injection gasoline engine of a laboratory vehicle
Assembly and disassembly exercises of the LPG and CNG system and its parts.
Emissions measurements of LPG and CNG fuel engine with the use of gas analyser.
Hybrid and Electric vehicles: Visualize and describe different parts, interfaces, sensors and communication buses on a vehicle in the Automotive Lab.

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<tr><td>Teaching</td><td colspan="3">Students are taught the course through lectures (2 hours per week) in classrooms or lectures theatres, by means of traditional tools or using</td></tr>
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Methodology	computer demonstration as well as laboratories (2 hours per week) that aim to combine the theory with the physical application. 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, design projects may be assigned to the students, where literature search is encouraged to identify a specific problem related to some issue, gather relevant scientific information about how others have addressed the problem, implement to implement the design and report the results in written or orally. Where appropriate, taught material as well as examples and design problems are drawn from the recent research activities of the lecturer or other faculty members.
Bibliography	• **<u>Textbooks:</u>** • Cornel Stan, **Alternative Propulsion for Automobiles**, Springer, 2016 • M. Ehsani et al**., Modern Electric, Hybrid Electric and Fuel Cell Vehicles**, **3rd edition**, CRC Press, 2018 • Amir Khajepour, M. Saber Fallah, Avesta Goodarzi, **Electric and Hybrid Vehicles. Technologies, Modelling and Control: a Mechatronics Approach,** Wiley 2014, ISBN: 978-1-118-34151-3 • Denton, T., ***"Electric and Hybrid Vehicles"***, Routledge, 2020. • Automotive Research and Design Company, ***"Hybrid and Electric Vehicle Propulsion Systems"***, 6th Edition, American Technical publishers Incorporated, 2010. • Gajendra Babu, M. K. & Subramanian, K. A., ***"Alternative Transportation Fuels: Utilisation in Combustion Engines"***, USA: CRC Press Publication, 2013. • **<u>References:</u>** • K. T. Chau, **Electric Vehicle Machines and Drives, Design Analysis and Application**, Wiley, 2015. • Tom Denton, **Electric and Hybrid Vehicles**, Institute of the Motor Industry, 2016 • J. Larminie and J. Lowry, Electric Vehicle Technology Explained, Wiley 2003 • Kwang Hee Nam, **AC Motor Control and Electrical Vehicle Applications, 2nd Edition**, Taylor & Francis, 2019
Assessment	The students are assessed via continuous assessment throughout the duration of the Semester, which forms the Coursework grade and the final

	written exam. The coursework and the final exam grades are weighted 65% and 35%, respectively, and compose the final grade of the course. Various approaches are used for the continuous assessment of the students, such as mid-term written exam, oral exam, quizzes, design assignments, design projects and laboratory experiments. 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: • Laboratories 25% • Class Quizzes 5% • Mid-Term written exams 10% • 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. The criteria considered for the assessment of each type of the continuous assessment and the final exam of the course are: (i) the comprehension of the fundamental concepts and theory of each topic, (ii) the application of the theory in solving related problems and (iii) the ability to apply the above knowledge in more complex design problems. The above criteria are weighted 30%, 40% and 30%, respectively. 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
Language	**English**