Course unit title:	Vehicle Internal Combustion Engines Design
Course unit code:	AU401
Type of course unit:	Compulsory
Level of course unit:	Bachelor (2^{nd} Cycle)
Year of study:	4
Semester when the unit is delivered:	7 (Fall)
Number of ECTS credits allocated :	6
Name of lecturer(s):	Dr. Charalambos Chasos
Learning outcomes of the course unit:	1. Explain the flow rate through valves and effects of valves lift and timing on volumetric efficiency. Describe the flow pattern related with the valves motion and positions. Analyse the inlet and exhaust valves opening overlap for various engine operating conditions. Assess the effects of manifold components characteristics on engine performance. Describe aspects for exhaust manifold design and exhaust gas recirculation strategies. 2. Describe the various injection systems integrated with the inlet manifolds and inlet valves (carburetors, indirect injection systems) for SI engines. Explain the direct injection systems and injection strategies for SI and Diesel engines and assess their effects on the inducted charge and in-cylinder gas motion. 3. Describe the general requirements for engine cooling via water or air cooling systems. Compare the differences between water or air cooling systems and identify the appropriate cooling systems for various engine applications. Describe the requirements and properties of the cooling agent and learn the characteristics and capacity of the cooling system components. Calculate engine heat transfer to the coolant and the cooling system components using heat transfer methodology. 4. List the general requirements for lubrication of the various engine components. Describe the types of lubrication and explain where these types occur in engines. Describe the lubricant characteristics for various engine operating conditions. Describe piston and rings assembly and their functions in engine operation. Distinguish different piston types and geometries and explain the corresponding induced in-cylinder gas flow. 5. Describe the different materials used for the cylinder block, engine head and pistons. Relate the imposed design constraints with the high temperatures taking place in engines. Describe the assembly of connecting rods, crankshaft and the distribution of power to auxiliary engine components. List the various mechanisms of camshafts and valves and explain their operation. 6. Describe the single-phase and two-phase flow conservation equations and their coupling for simulation of the fuel injection and air/fuel mixture preparation and combustion process taking place is SI and Diesel engines. Analyse the burn rate and explain the heat release rate history estimated from CFD engine simulations. Simulate induction and spray processes with Computational Fluid Dynamics (CFD) code. 7. Describe experimental measurement techniques and facilities for ICE engine measurements. Describe the engine test bed facilities used for ICE testing and characterization. 8. Apply exhaust gas measurement techniques. Explain the oxygen and air/fuel ratio analysis, the exhaust gases composition, smoke and particulates emitted by SI and Diesel engines and explain the corresponding engine behaviour and performance with varying engine performance parameters.

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<tr><td>Mode of delivery:</td><td colspan="3">Face-to-face</td></tr>
<tr><td>Prerequisites:</td><td>AU302, AU309</td><td>Co-requisites:</td><td>None</td></tr>
<tr><td>Recommended optional program components:</td><td colspan="3">None</td></tr>
<tr><td>Course contents:</td><td colspan="3">Induction and Exhaust process: Dynamics behaviour of valve gear, effects of valve timing, inlet and exhaust manifold design, exhaust gas recirculation strategies. Catalysts technology, after-treatment and catalytic converters. Air/fuel mixture preparation via appropriate injection systems (SI and Diesel engines), integration of injection systems, injection strategies

Cooling System: General requirements, requirements and properties of cooling agent, design and calculation of cooling system elements

Lubrication System: General requirements, design and calculation of lubricating system elements

Mechanical Design considerations: Cylinder block and head materials, piston and rings, connecting rods, crankshaft, camshaft and valves

Engine Modelling: Induction and Exhaust processes, Fuel injection and air/fuel mixture preparation, combustion process, burn rate, Engine Friction. Case studies and applications

Experimental Facilities: Dynamometers, fuel consumption measurement, air flow rate, Temperature and pressure, Energy balance, Oxygen and Air/fuel ratio analysis, Exhaust gases, smoke and particulates

Laboratory Work (experimental): Small group experiments investigating the effects of varying engine technical and/or engine operational parameters on the engine performance for wide range of engine operating conditions. A selection from the following experiments is performed during the course:

- Port/Valve geometry and valve timing effects on volumetric efficiency and performance of a single cylinder ICE.
- Injection duration, pressure, timing effects on the performance of a single cylinder ICE.
- Injector type and injector operating characteristics effect on the performance of a single cylinder ICE.
- Engine head and piston type effect on the performance of a single cylinder ICE.
- Bioethanol fuel blend percentage effect on the performance and emissions of a SI engine.
- Biodiesel fuel blend percentage effect on the performance and emissions of a Diesel engine.

Laboratory work (design): Individual ICE design project concerned with the induction and exhaust system, cylinder and piston selection and sizing (or other engine system/component) for conventional vehicle engines, where effects of variation of geometrical and operational design parameters are considered.

Laboratory work (simulation): Individual ICE simulation project concerned with the full engine modelling setup (three-dimensional geometry and models selection) and engine flow processes simulation via Computational Fluid Dynamics (CFD) performed with state-of-the-art CFD code.</td></tr>
<tr><td>Recommended and/or required reading:</td><td colspan="3">Heat transfer, thermodynamics and principles of fluid mechanics, ICE theory, computed aided design methodology</td></tr>
<tr><td>Textbooks:</td><td colspan="3">1. Richard Stone. “Introduction to Internal Combustion Engines”. Palgrave Macmillan, 1999
2. Colin R. Ferguson. “Internal Combustion Engines”. John Wiley and</td></tr>
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	Sons, 2000 3. John B. Heywood. ***"Internal Combustion Engine Fundamentals"***. McGraw Hill Education, 1989.
Planned learning activities and teaching methods:	The course is delivered to the students by means of lectures, conducted with the help of computer presentations, as well as execution of experiments on ICE in the ICE Laboratory, and ICE design with the use of computer aided design (CAD) software and ICE simulations with CFD code in the Computer Laboratory. Lecture notes and presentations are available through the web for students to use in combination with the textbooks.
Assessment methods and criteria:	• Assignments 10% • Laboratories 10% • Tests 20% • Final Exam 60%
Language of instruction:	English
Work placement(s):	No