COURSE DESCRIPTION

Course Title	Vehicle Internal Combustion Engines Design				
Course Code	AU401				
Course Type	Compulsory				
Level	BSc (Level 1)				
Year / Semester	4th/Fall				
Teacher's Name	Dr. Charalambos Chasos				
ECTS	6	Lectures / week	3	Laboratories/week	1
Course Purpose	The course purpose is to teach students how to design four-stroke internal combustion engines (ICE) which power automotive vehicles, as well as analyse and design the various components that an ICE consist of. Furthermore, the course aims to teach the students how to model and calculate the various processes taking place in ICE, including spray injection and air/fuel mixing, heat transfer, air intake and exhaust systems flows, for various operating conditions. In addition, the course prepares the students in order to select and use state-of-the-art modelling methods and computational fluid dynamics code for the modelling and simulation of ICE. The present course belongs in the BSc. in Automotive Engineering programme and provides advanced and specialized knowledge of ICE design, calculation, modelling and simulation which is required for automotive engineers working in research and development of ICE.				
Learning Outcomes	By the completion of the course, the students should be able to: 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. 2. Assess the effects of manifold components characteristics on engine performance. Describe aspects for exhaust manifold design and exhaust gas recirculation strategies. 3. 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. 4. Explain 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. 5. 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. 6. 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. 7. Calculate the engine and components dimensions for certain engine design requirements, by synthesizing information from engine theory and engine data and engine components data from the literature. 8. Design the main parts of ICE and assemble the full three-dimensional engine geometry by the use of calculations and the employment of computer-aided design (CAD) software (Solidworks). 9. 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. 10. Summarise the experimental measurement techniques and facilities for ICE engine measurements. Describe the engine test bed facilities used for ICE testing and characterization.		
Prerequisites	AU302, AU309	Corequisites	None
Course Content	**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. Compuational fluid dynamics methodology (single phase, two-phase, reacting flows) and computational fluid dynamics codes. **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 **Assignment (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 the STAR-CD CFD code.
Teaching Methodology	The course is delivered to the students by means of lectures, exercises solution on the whiteboard, conducted with the help of computer presentations, as well as demonstrations of various ICE desings and components designs from the literature. Furthermore, CFD simulation results for various ICE and components (injectors, intake systems etc.) are demonstrated. Lecture notes and presentations are available through the E-learn site of the course for students to use in combination with the textbooks and references.
Bibliography	**(a) <u>Textbooks:</u>** 1. Charles Fayette Taylor. "The Internal Combustion Engine in Theory and Practice, Volume 2: Combustion, Fuels, Materials, Design", Revised Edition, MIT Press, 1999. **(b) <u>References:</u>** 1. Colin Ferguson, Allan Kirkpatrick. "Internal Combustion Engines". John Wiley and Sons, 2000. 2. Richard Stone. "Introduction to Internal Combustion Engines". Palgrave Macmillan, 1999. 3. John B. Heywood. "Internal Combustion Engine Fundamentals". McGraw Hill Education, 1989.
Assessment	**<u>(a) Methods:</u>** • Assignment (design) 10% • Laboratory report 10% • Mid-term examination 20% • Final Exam 60% **<u>(b) Criteria:</u>** • The assessment criteria are included in the edited documents of the laboratory exercises and the edited document of the assignment. In particular, the clarity of the content and writing, the structure, the quality of graphs, tables and data analysis illustration, the discussion and conclusions are assessed. • The mid-term exam is done during the seventh week of the semester, which assesses the students' performance on the subject matter taught during the first six weeks of the semester. Two questions ask for engine diagrams, engine performance graphs and calculations which are assessed on the correctness, clarity, results

	and units used. • The final exam includes four questions (theoretical and analytical) and assesses students on the subject matter of the course and their ability to design ICE and engine components, to draw diagrams and graphs, carry out calculations and compare and discuss the results.
Language	English