Course unit title:	Computational Fluid Dynamics (CFD) methodology and applications		
Course unit code:	AU310		
Type of course unit:	Compulsory		
Level of course unit:	Bachelor (1st Cycle)		
Year of study:	3		
Semester when the unit is delivered:	6 (Spring)		
Number of ECTS credits allocated :	6		
Name of lecturer(s):	Dr. Charalambos Chasos		
Learning outcomes of the course unit:	1. Formulate and solve fluid flow and heat transfer problems. Calculate fluid flow and heat transfer data and construct plots of fluid flow and heat flux fields. Compare fluid flow and heat transfer behaviour in various geometries for wide range of conditions. 2. Explain factors influencing the fluid flow and/or heat transfer, and describe the corresponding effects of flow and heat transfer on the performance and efficiency of the associated system. 3. Identify and use methodologies for modelling, simulating and carrying out parametric studies for the design and development of thermal and/or fluid flow systems, both for internal and external flows. 4. Write problem equations and use different discretisation methods for the discretisation of equations at a grid. Describe differencing schemes and use direct and indirect methods for the numerical solution of linear system of equations. 5. Design problem geometry and grid, specify boundary and initial conditions, write computer programme and solve numerically the problem. Visualise the results and describe validation against analytical solution or experimental data. 6. List advanced grid generation techniques, turbulence modelling, solution algorithms and advanced CFD approaches		
Mode of delivery:	Face-to-face		
Prerequisites:	ME200, ME202	Co-requisites:	None
Recommended optional program components:	None		
Course contents:	**Introduction:** Principles of fluid mechanics, heat transfer and thermodynamics. Fluid flow and heat transfer problems, analytical and numerical solutions. Fluid flow and heat transfer problems formulation and computer programming solution. Problem solving with CFD computational codes and practical examples. Aspects of FORTRAN and MATLAB programming languages. **Classification of fluid flow**: External and internal flows. Steady and unsteady state problems. Inviscid and viscous flow. Laminar and turbulent flow. Incompressible and compressible flow. Subsonic and supersonic flow. Summary of problem types and equations. **Conservation equations for fluid flow and heat transfer:** Mass, momentum and energy conservation equations differential form. Mass, momentum and energy conservation equations integral form. **Boundary and initial conditions:** Boundary conditions for steady and unsteady flows. Initial conditions for unsteady flows. **Discretisation techniques:** The finite-difference method and applications. The finite-volume method and differencing schemes. Application of the finite-volume method in diffusion problems. Application of the finite-volume method in convection-diffusion problems.		

	Solution techniques of discretised equations: Summary of the FV method coefficients/sources and the resulting linear system of equations. Direct methods and application of the tridiagonal matrix algorithm (TDMA). Indirect methods and application of the Jacobi iteration method. Properties of numerical solution methods and error estimation. **Advanced topics in CFD**: Grid generation. Turbulence modelling and the Naviers-Stokes equations averaging. Solution algorithms for pressure-velocity coupling. Large Eddy Simulation (LES). Direct numerical simulation (DNS). **Laboratories:** Individual simulation Laboratories for practical fluid flow problems solution and plots of field data performed with the use of the CFD code STAR-CD at the Computer Laboratory. **Assignments:** Individual assignment for diffusion or convection-diffusion problems solution with the finite-volume method and appropriate differencing schemes and application of numerical technique via the use of programming language (FORTRAN or MATLAB).
Recommended and/or required reading:	Thermodynamics and principles of fluid mechanics, numerical methods, computer programming
Textbooks:	1. Versteeg H. K. and Malalasekera, W. "***An introduction to Computational Fluid Dynamics – The Finite-Volume Method***". 2nd Edition, Prentice Hall, England, 2. Ferziger, J. H and Peric, M. "***Computational Methods for Fluid Dynamics***". 2nd Edition,Springer, Germany, 1999. 3. Potter, M. C. and Wiggert, D. C. "***Mechanics of fluids***". 3rd Edition, Prentice Hall, USA, 2002 4. Incropera, F. P. and DeWitt, D. P. "***Fundamentals of heat and mass transfer***", 5th Edition, John Wiley & Sons, USA, 2002 5. Ellis, T. M. R. "***A structured approach to FORTRAN 77 programming***". Addison-Wesley, England, 1982 6. Biran, A. and Breiner M. "***MATLAB 6 for engineers***", 3rd Edition, Prentice Hall, 2002
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 demonstrations of computational geometries, models, computer programmes and the use of advanced CFD code at the computer laboratory for solving fluid flow and heat transfer problems. 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% • Test 20% • Final Exam 60%
Language of instruction:	English
Work placement(s):	No