<table>
<tr><td>Course Title</td><td colspan="5">Industrial modelling and simulation</td></tr>
<tr><td>Course Code</td><td colspan="5">OG404</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">4th/Spring</td></tr>
<tr><td>Teacher’s Name</td><td colspan="5">Dr. Charalambos Chasos</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 course purpose is firstly to educate students in the modelling and simulation of flow processes present in the Oil&Gas industry, with the use of computational fluid dynamics codes. Secondly, it aims to train the students in the modelling and simulation of the industrial processes in Oil&Gas industry including chemical reactors, separators etc. with the use of commercial process simulators and processes flowsheets. The present course belongs in the BSc. in Mechanical Engineering programme with Specialisation in Oil&Gas Engineering and provides advanced modelling and simulation knowledge to the students.</td></tr>
<tr><td>Learning Outcomes</td><td colspan="5">By the completion of the course, the students should be able to:
1. Formulate and solve fluid flow and heat transfer problems with the use of commercial computational fluid dynamics codes,
2. Carry out simulations and compare fluid flow and heat transfer phenomena occurring in various geometries for wide range of operating conditions.
3. Select and use methodologies for the modelling and simulation of industrial flow processes at which pure or multicomponent fluids are studied.
4. Perform parametric studies for the design and development of thermal and/or fluid flow systems and/or process systems, by applying advanced methodologies available in computer codes.
5. Formulate flowsheets of industrial processes such as oil and gas processing for various process systems and different operating conditions.
6. Practice and familiarise with commercial process simulators.
7. Describe the design of process systems and relate with data obtained from process simulators.
8. Implement equations in computer programmes and solve numerically fluid flow, heat transfer and process systems problems.</td></tr>
<tr><td>Prerequisites</td><td colspan="2">ME200, ME202</td><td colspan="2">Corequisites</td><td>None</td></tr>
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Course Content	<u>**Part A: Flow processes modelling and simulations**</u> **Classification of fluid flow and heat transfer problems:** Steady and unsteady state problems. Inviscid and viscous flow. Laminar and turbulent flow. Incompressible and compressible flow. Multiphase flows. Summary of problem types and equations. **Conservation equations for fluid flow and heat transfer:** Mass, momentum and energy conservation equations differential and integral form. Discretisation techniques: The finite-difference method. The finite-volume method and differencing schemes. Boundary conditions for steady and unsteady flows. Initial conditions for unsteady flows. Solution techniques of discretised equations: direct methods and indirect methods. **Computational fluid dynamics (CFD) codes:** industrial applications with commercial codes. Problems formulation and computer programming solution with programming language (FORTRAN or MATLAB). Complex geometry grid generation. The Navier-Stokes equations and turbulence modelling equations averaging. Large Eddy Simulation (LES). Direct numerical simulation (DNS). <u>**Part B: Industrial processes modelling and simulations**</u> **Classification of industrial processes:** Chemical reactor systems, separation systems, compression systems and heat exchangers. Practical examples (flash distillation, extraction, gas absorption and adsorption). Aspects of design and integration of various process systems. Energy and environmental concepts in industrial processes. **Process modelling:** Equations of state, thermophysical properties models, vapor/liquid equilibrium equations, chemical reaction equations, mass and energy balances. Process heat transfer equations. Aspects of processes flowsheet formulation. **Process simulation:** Steady state calculations approach with commercial simulator tools application and implementation of processes flowsheets. Data visualisation and analysis. Performance and efficiency assessment from process simulations. Introduction in dynamic process simulations. **Laboratories:** Individual simulation Laboratories for industrial fluid flow and/or heat problem with the use of state-of-the-art commercial CFD code at the Computer Laboratory. Individual process simulation problem with the use of state-of-the-art commercial process simulator at the Computer Laboratory. **Assignments:** Individual assignment for fluid flow and heat transfer problem with the finite-volume method. Individual assignment for solving the equilibrium equations for a flash phase separator example. Assignments solution with the use of programming language (FORTRAN or MATLAB) and a spreadsheet.

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 geometries of industrial systems, meshes and CFD simulations with the CFD code STAR-CD and demonstrations of system processes modelling and simulation with the ASPEN-PLUS process simulator. 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. Versteeg H. K. and Malalasekera, W. "An introduction to Computational Fluid Dynamics – The Finite-Volume Method". 2nd Edition, Prentice Hall, England, 2007. 2. Smith, R. "Chemical process design and integration", John Wiley & Sons Ltd, England, 2005. **(b) <u>References:</u>** 1. Ferziger, J. H and Peric, M. "Computational Methods for Fluid Dynamics". 2nd Edition,Springer, Germany, 1999. 2. Potter, M. C. and Wiggert, D. C. "Mechanics of fluids". 3rd Edition, Prentice Hall, USA, 2002 3. Incropera, F. P. and DeWitt, D. P. "Fundamentals of heat and mass transfer", 5th Edition, John Wiley & Sons, USA, 2002 4. Crowe, C., Sommerfeld, M. and Tsuji, Y. "Multiphase flows with droplets and particles", CRC Press, USA, 1998. 5. Ellis, T. M. R. "A structured approach to FORTRAN 77 programming". Addison-Wesley, England, 1982 6. Finlayson, B. A. "Introduction to chemical engineering computing", 2nd Edition, John Wiley & Sons Inc., USA, 2012. 7. Biran, A. and Breiner M. "MATLAB 6 for engineers", 3rd Edition, Prentice Hall, 2002.
Assessment	**<u>(a) Methods:</u>** • Assignments 10% • Laboratory reports 10% • Mid-term examination 20% • Final Exam 60% **<u>(b) Criteria:</u>** • The assessment criteria are included in the edited documents of the assignments and the laboratory exercises. In particular, the clarity of the content and writing, the structure, the methodology description, the quality of results plots and calculations, 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 the application of methods for fluid flow and/or heat transfer calculation and process modelling and calculation. The students are assessed on the correctness of the methodology and calculations, the diagrams and their results discussion. • The final exam includes four questions (theoretical and analytical) and assesses students on the subject matter of the course and their ability to apply methods, carry out calculations, define and present processes calculations and explain their results.
Language	English