1. GENERAL INFORMATION

1.1. Course teacher	Associate Professor Domagoj Vulin, PhD		1.6. Year of the study	II
1.2. Name of the course	Reservoir simulation		1.7. ECTS credits	5
1.3. Associate teachers	-		1.8. Type of instruction (number of hours L + E + S + e-learning)	18L+15E+15S+12e-learning
1.4. Study programme (undergraduate, graduate, integrated)	graduate		1.9. Expected enrolment in the course	15
1.5. Status of the course	☐ mandatory	☒ elective	1.10. Level of application of e-learning (level 1, 2, 3), percentage of online instruction (max. 20%)	level 3, 20% online

2. COUSE DESCRIPTION

2.1. Course objectives	By taking the exam, the student will know the structure of the reservoir simulator, the way in which numerical calculations of processes in the reservoir are formulated, and the method of reservoir modeling, from data preparation to history matching with production reservoir data and visualization of simulation results.
2.2. Enrolment requirements and/or entry competences required for the course	-
2.3. Learning outcomes at the level of the programme to which the course contributes	Independently solve complex engineering problems in petroleum engineering and geoenergy engineering; Plan hydrocarbon and geothermal reservoir management; Predict reservoir behaviour and the behaviour of hydrocarbon and geothermal water production system; Optimize hydrocarbon and geothermal water production; Appraise projects in petroleum engineering and geoenergy engineering.
2.4. Expected learning outcomes at the level of the course (3 to 10 learning outcomes)	Select the necessary set of data for certain calculations, ie reservoir-development methods; Oppose the most popular production calculation methods, ie comparisons of production history; Format statistically valid set of data for reservoir engineering calculations; Structure and initialize the simulation model; To match individual measured or recorded data with the analytical, and simulation model; Apply methods of prediction of recovery from hydrocarbon reservoirs using reservoir engineering methods; Show examples of numerical calculation of pressure drop in reservoirs.

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2.5. Course content (syllabus)	**Production prediction methods:** Overview of reservoir behavior prediction methods; Revision of material balancing calculations in a reservoir - an example of Craig's multi-well calculation; Overview of terms and data related to dynamic reservoir description - petrophysical parameters; Statistical processing of permeability, porosity, relative permeability, capillary pressure data for analytical and simulation applications; Possible data sources (laboratory measurements, correlations, processed laboratory data, data related to production history); Concepts and data related to dynamic reservoir description - pVT parameters (tables or equations of state); **Examples of numerical calculation:** Example of a numerical calculation for heat transfer in a two-dimensional layer; Calculation of the spatial distribution of heat based on the Laplace equation; Theory of numerical flow calculation; An example of the equation of left, right and central finite differences for the flow account between two elements; Example of numerical flow calculation in a two-dimensional model; Example of numerical calculation for pressure in a two-dimensional model; Numerical solution of pressure drop in 2D model (MS Excel); **Simulation models:** Structure of simulation model in modern reservoir simulators - required data sets, types of networks (gridding), aquifer models (numerical aquifer, Fetkovich aquifer, explicitly defined aquifer), definition of well equipment (transmissibility, flow conditions, boundary pressure condition); Data preparation for the reservoir simulator - comparison of the input data structure in the Schlumberger Eclipse simulator and CoatsEngineering SENSOR; Example of an oil model in a numerical simulator (ECLIPSE, SENSOR, BOAST4D); Creation of different types of networks (uniform Cartesian = block-centered, structural = corner-point, cylindrical coordinates, combination of networks); Simulation of a simple example (block model) model in Eclipse - presentation of results (pressure drop in time, production, daily production, saturation in 3D space, pressure changes in 3D space); Initialization of the simulation model (matching of the initial state of saturation and pressures of the simulation model with the predicted, ie measured data); Matching of production history and simulation model - an example of history-matching the simulation model with pressure drop calculations by material balancing; Development of a block model in Eclipse and comparison with the material balancing calculation made within the course Hydrocarbon reservoir development; Matching of reservoir simulation parameters with material balance calculation - segmented model, modeling of porosity changes, heterogeneity; Seminar project assignment (upscaling and stochastic modeling of data, matching of models with Craig's calculation, matching with Buckley-Leverett's calculation, etc.); Translation (upscaling, homogenization) of laboratory data to the level of the reservoir - coreflood simulation, ie harmonization of the simulation model with laboratory measurement of relative permeability; Project assignment: development of a simulation model based on the initialized reservoir model and given production data; Project task: cost-effectiveness of an individual simulation scenario - selection of the most efficient model (ie the one that gives the highest recovery with the least number of wells in the optimal time); Changing the resolution of a reservoir model - examples of the influence of numerical error on the result. Solution convergence problems; Statistical quantification of heterogeneity and application to a reservoir model with a large number of simulation cells; Scales of model definition, a simple example of data homogenization (upscaling); Stochastic approach to predict data not available for the model and grid refinement with a large number of cells; Development of a miscible flow model (for enhanced, ie tertiary methods); Example of application of the compositional models, comparison with previous developed (black oil) simulation models; Project assignment: Matching production histories in a compositional model; Scenario analysis of future hydrocarbon production.

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2.6. Format of instruction:	☒ lectures ☒ seminars and workshops ☒ exercises ☐ online in entirety ☒ partial e-learning ☒ field work	☒ independent assignments ☒ multimedia and the internet ☐ laboratory ☒ work with mentor ☐ (other)	2.7. Comments: -
2.8. Student responsibilities	The student should regularly attend exercises and submit a seminar paper according to the prescribed format.		

2.9. Monitoring student work									
	Class attendance	YES		Research	YES		Oral exam	YES	
	Experimental work		NO	Report		NO			
	Essay		NO	Seminar paper	YES				
	Preliminary exam	YES		Practical work	YES				
	Project	YES		Written exam		NO	ECTS credits (total)	5	

2.10. Required literature (available in the library and/or via other media)	**Title**	**Number of copies in the library**	**Availability via other media**
	Koederitz, L.F. (2005.): *Lecture notes on applied reservoir simulation*.	NO	YES
	SPE Comparative Studies (1 to 10)	NO	YES
	Gilman, J.R., Ozgen, C. (2013.): *Reservoir simulation: history matching and forecasting* (p. 109). Richardson, TX: Society of Petroleum Engineers.	NO	YES
	Satter, A., Iqbal, G.M. (2015.): *Reservoir Engineering: The Fundamentals, Simulation, and Management of Conventional and Unconventional Recoveries*, Gulf Professional Publishing.	NO	YES

2.11. Optional literature	-
2.12. Other (as the proposer wishes to add)	The course is held through an overview of reservoir simulation methods, each accompanied by an explanation of the goal of the study as the terms of reference for project problem to be solved in groups ("case study"). As experts in this field must work in teams, special attention will be paid to each new selection of groups for the next project task, which will be carried out for each student through an evaluation of the qualities needed for teamwork (individuality / teamwork, occasional initiative / continuous work, organization, creativity).

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