## Course Title (in English)
Geostatistics and Reservoir Simulation

## Course Title (in Russian)
Геостатистика и моделирование процессов разработки

## Lead Instructor(s)
Koroteev, Dmitri

## Is this syllabus complete, or do you plan to edit it again before sending it to the Education Office?
The syllabus is a final draft waiting for approval (once approved the syllabus will be published on the public web-site and other systems)

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Dmirty Koroteev

## Contact Person’s E-mail
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### 1. Annotation

## Course Description

The course includes lectures in reservoir simulation, history matching, and fundamentals of geostatistics. Reservoir simulation and history matching embrace the following:
1) Fundamentals of single-phase and multiphase multicomponent fluid flow and storage in reservoirs
2) Numerical solution of governing equations using finite difference
3) Introduction to inverse theory and history matching
4) Simulating of laboratory PVT data by Equation Of States (EOS)

Fundamentals of geostatistics include the following:
1) Stochastic reservoir simulation
2) Statistical measures
3) Univariate and multivariate Statistics
4) Covariance and variograms
5) Sequential Gaussian simulation
6) Uncertainty quantification

Finally, reservoir simulation and geostatistical analysis are integrated for risk analysis and economy estimation. Laboratory computational exercises are also included.

## Course Prerequisites / Recommendations

- Basics of Statistics and Probability Theory
- Basics of Petroleum, Reservoir Physics and Oil Field Development
- Fundamentals of Hydrocarbon Phase Behavior
- Experience with Eclipse, tNavigator is a plus but is not mandatory
- Experience with Python programming language is also plus but not mandatory
## 2. Structure and Content

**Course Academic Level**: Master-level course suitable for PhD students

**Number of ECTS credits**: 6

<table>
<thead>
<tr>
<th>Topic</th>
<th>Summary of Topic</th>
<th>Lectures (# of hours)</th>
<th>Seminars (# of hours)</th>
<th>Labs (# of hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intro to Reservoir Simulation</td>
<td>This topic includes reservoir engineering techniques for forecast, reserves estimation and reservoir behavior prediction. We will discuss analogues, decline curves analysis, material balance, reservoir simulation background (history), model purposes, model contents vs. complexity and reservoir model elements.</td>
<td>2</td>
<td>2</td>
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</tr>
<tr>
<td>Reservoir Simulation on Practice</td>
<td>This topic includes practice over advanced examples with reservoir model components, work over static model, grid, rock property modelling, dynamic model implementation, major laws used in reservoir simulation, numerical techniques in reservoir simulation and scaling/upscaling.</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Equations of State and Phase Equilibria</td>
<td>In this lectures and seminars we will review the field of volumetric equations of state for fluidics, their origin, the mixing and combining rules that allow their application to mixtures, and the use of such models for the calculation of phase equilibrium and thermodynamics properties.</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Intro to Inverse Theory and History Matching</td>
<td>In this section we will discuss the using of inverse theory for estimation and conditional simulation of flow and transport parameters in porous media. It describes the theory and practice of estimating properties of underground petroleum reservoirs from measurements of flow in wells, and it explains how to characterize the uncertainty in such estimates.</td>
<td>2</td>
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<td>2</td>
</tr>
<tr>
<td>Intro to Geostatistics</td>
<td>In this section we will discuss practical consequences of variability phenomena, basis of stochastic methods. Participants will be introduced to statistical and probabilistic methods applied in geosciences.</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Kriging and Sequential Gaussian Simulation</td>
<td>Here we will discuss geostatistical procedure (Kriging) doing the estimation of parameter values at unsampled locations, and/or the estimation of the average of the parameter over a certain area. Also we will discuss sequential Gaussian Simulation. And give the comparison of two popular techniques.</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Uncertainty Modeling and Sensitivity Analysis</td>
<td>Here we look at the methods of Uncertainty Modeling and Sensitivity Analysis on real examples.</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Consultation with professor during summative assessment period</td>
<td>In this period students can clarify some non-understandable moments during previous learning trajectory. This is consultations for all students.</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
This part is dedicated to testing intermediate knowledge. It will consist of several parts. The first part is written, the second part in the form of a test, and the third part is the task with calculations.

This part is devoted to deep immersion in the real problems of the industry. Here we discuss the details of potential potential final projects.

This part is important in preparing for the final project. Also, meetings with the instructor are foreseen during this period to assess the final goals and objectives, the intermediate results of the project.

In this part of the project, trainers evaluate the final project, which will consist of a presentation of the results and a final report.

### 3. Assignments

<table>
<thead>
<tr>
<th>Assignment Type</th>
<th>Assignment Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>Homework on Introduction To Reservoir Simulation</td>
</tr>
<tr>
<td>Homework</td>
<td>Homework on Reservoir Simulation on Practice</td>
</tr>
<tr>
<td>Homework</td>
<td>Homework on Advanced PVT</td>
</tr>
<tr>
<td>Homework</td>
<td>Homework on Introduction to Inverse Theory and History Matching</td>
</tr>
<tr>
<td>Homework</td>
<td>Homework on Introduction to Geostatistics</td>
</tr>
<tr>
<td>Homework</td>
<td>Homework on Kriging and Sequential Gaussian Simulation</td>
</tr>
<tr>
<td>Homework</td>
<td>Homework on Uncertainty Modeling and Sensitivity Analysis</td>
</tr>
<tr>
<td>Project</td>
<td>Course Project (TBA)</td>
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### 4. Grading

<table>
<thead>
<tr>
<th>Type of Assessment</th>
<th>Graded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade Structure</td>
<td></td>
</tr>
<tr>
<td>Activity Type</td>
<td>Activity weight, %</td>
</tr>
<tr>
<td>Homework Assignments</td>
<td>70</td>
</tr>
<tr>
<td>Final Project</td>
<td>30</td>
</tr>
</tbody>
</table>

### Grading Scale

- **A:** 86
- **B:** 71
5. Basic Information

### Maximum Number of Students

<table>
<thead>
<tr>
<th>Maximum Number of Students</th>
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</thead>
<tbody>
<tr>
<td>Overall: 40</td>
</tr>
<tr>
<td>Per Group (for seminars and labs): 40</td>
</tr>
</tbody>
</table>

### Course Stream

Science, Technology and Engineering (STE)

### Course Term (in context of Academic Year)

Term 4

### Course Delivery Frequency

Every year

### Students of Which Programs do You Recommend to Consider this Course as an Elective?

<table>
<thead>
<tr>
<th>Masters Programs</th>
<th>PhD Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum Engineering</td>
<td>Petroleum Engineering</td>
</tr>
</tbody>
</table>

### Course Tags

Programming, Engineering, Petroleum

6. Textbooks and Internet Resources

<table>
<thead>
<tr>
<th>Required Textbooks</th>
<th>ISBN-13 (or ISBN-10)</th>
</tr>
</thead>
</table>
## Recommended Textbooks

<table>
<thead>
<tr>
<th>Title</th>
<th>ISBN-13 (or ISBN-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverse theory for Petroleum Reservoir Characterization and History Matching (Dean S. Oliver; Albert C. Reynolds; Ning Liu)</td>
<td>9781108462075</td>
</tr>
<tr>
<td>Equations of State and PVT Analysis Applications for Improved Reservoir Modeling, Ahmed T. Second Edition 2016</td>
<td>9780128015704</td>
</tr>
</tbody>
</table>

## 7. Facilities

### Software

Anaconda Distribution with Python 3.6 (download from https://www.anaconda.com/download)

## 8. Learning Outcomes

### Knowledge

Mathematical and scientific knowledge in modern methods and geostatistic tools. Knowledge of applied science, reservoir engineering including programming, reservoir simulation, etc. Understanding the global public, environmental and business context.

### Skill

Ability to assess prospects and possibilities for the use of scientific and technological progress achievements in the innovative development of the sector, come up with ways of their implementation. Ability to perform calculations on projects, technical and economic and functional cost analysis to assess performance of the designed equipment, hardware, and technological processes. Readiness to prepare geostatistical tools for methods of prospecting and development of complex hydrocarbon reserves. Ability to communicate in an international environment.

### Experience


## 9. Assessment Criteria

Input or Upload Example(s) of Assignment 1:

Select Assignment 1 Type: Homework Assignments
Or Upload Example(s) of Assignment 1
https://ucarecdn.com/15617191-20a5-40e4-a03f-3c25d0f95425/

Assessment Criteria for Assignment 1

1) Style and Clarity:
State the assignment name and number; due date; brief description; student name. Show work; state assumptions.
2) Correctness and clarity:
Solution correctness. Clarity, conciseness. Completeness. The solution should address all aspects inherent in the problem.
3) Lateness:
10% of total possible points will be subtracted for each day an assignment is late: 10% for one day late; 20% for two days late; 30% for three days late; 40% for four days late; 50% for five days late. An assignment more than 5 days late will not be scored, but it should be handed in and may be used as an aid in determining a student's overall grade.

Input or Upload Example(s) of Assignment 2:

Select Assignment 2 Type
Final Project

Input Example(s) of Assignment 2 (preferable)

Assessment Criteria for Assignment 2

1) Style and Clarity of presentation
2) Correctness and clarity
3) Innovation part of the proposed project
4) Impact of results on industry
3) Q&A session

Input or Upload Example(s) of Assignment 3:

Input or Upload Example(s) of Assignment 4:

Input or Upload Example(s) of Assignment 5:

10. Additional Notes

Free Style Comments (if any)
The difference between PhD and Ms programme is in the complexity of homework tasks and in the complexity of final course project.
Homework tasks may be sent as an Anaconda Notebook or Python code with a report in .doc or .pdf attached
Final project requires code, presentation and report (first and third may be done using Anaconda notebook)