# Course Syllabus

<table>
<thead>
<tr>
<th>Course Title (in English)</th>
<th>Permafrost and Natural Hydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Title (in Russian)</td>
<td>Многолетнемерзлые породы и природные гидраты</td>
</tr>
<tr>
<td>Lead Instructor(s)</td>
<td>Evgeny Chuvilin</td>
</tr>
<tr>
<td>Is this syllabus complete, or do you plan to edit it again before sending it to the Education Office?</td>
<td>The syllabus is a final draft waiting for approval (once approved the syllabus will be published on the public web-site and other systems)</td>
</tr>
<tr>
<td>Contact Person</td>
<td>Evgeny Chuvilin</td>
</tr>
<tr>
<td>Contact Person’s E-mail</td>
<td><a href="mailto:E.Chuvilin@skoltech.ru">E.Chuvilin@skoltech.ru</a></td>
</tr>
</tbody>
</table>

## 1. Annotation

### Course Description

This course is about permafrost and natural hydrates. You will learn The course is devoted to the consideration of cryogenic-geological conditions of the northern oil and gas provinces of Russia and their influence on the construction and operation of production wells. The course includes permafrost characterization within the main oil and gas fields in the European North and Siberia, including the Arctic zone. The main cryogenic-geological processes occurring in the areas of permafrost propagation are considered. The description of gas and gas hydrate accumulations in permafrost is given. The conditions for the formation and existence of gas and gas hydrate accumulations in permafrost are analyzed. Zoning of the territories of oil and gas provinces on the complexity of geocryological conditions for the development of deposits is carried out. The characteristic of engineering and permafrost studies for the selection of construction sites for producing wells is given. Analyzed the complications arising from the construction and operation of wells in permafrost. Thermal and mechanical interaction of producing wells with permafrost is considered. The behavior of gas hydrate accumulations in permafrost zone during the development of gas and oil fields in the Arctic is analyzed. The impact of global climate change on the stability of wells and ground engineering structures of the oil and gas complex is assessed.

### Course Prerequisites / Recommendations

No prerequisites
## 2. Structure and Content

<table>
<thead>
<tr>
<th>Course Academic Level</th>
<th>Master-level course suitable for PhD students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of ECTS credits</td>
<td>3</td>
</tr>
</tbody>
</table>

<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>Permafrost as an area of oil and gas production</td>
<td>The concept of the permafrost of the Earth. Geocryology as a science studying the formation and evolution of permafrost. Basic concept and definitions in geocryology. Distribution and thickness of permafrost. Permafrost and its connection with natural gas hydrates.</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characterization of permafrost</td>
<td>Features of the organo-mineral skeleton of frozen sediments. The icy component of frozen rocks. Unfrozen water in frozen sediments. Dependences in changes of the unfrozen water content. Gas and gas hydrate component of frozen sediments.</td>
<td>1.5</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Phase transitions in freezing sediments, the structure of frozen sediments</td>
<td>Mechanisms of ice formation in sediments. Mass transfer and ice formation in cryogenic sediments. Dependances of formation of macro- and microstructure of frozen sediments. Classifications of cryogenic textures</td>
<td>1.5</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Formation and dynamics of permafrost</td>
<td>Frozen sediments as a result of zoning, altitudinal zonation, and heat and mass transfer processes on the earth’s surface and in the atmosphere. Influence of boundary conditions on the formation of thickness and temperature regime of frozen strata.</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Features of the geocryological conditions formation</td>
<td>Taliks in the permafrost zone. The causes and conditions of the formation, existence and evolution of taliks. Groundwater in permafrost. Seasonal thawing and seasonal freezing of sediments. Dependances of spatial and temporal variability of the depth of seasonal thawing and seasonal freezing. Zoning of territories of oil and gas provinces by the complexity of geocryological conditions</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cryogenic processes and phenomena</td>
<td>Frosty heaving (pingo formation) of dispersed sediments and forms of its manifestation. Frost cracking and polygon-vein structures. Thermokarst and thermokarst drawdowns. Slope processes and phenomena</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>The formation and decomposition of gas hydrates in sediments</strong></td>
<td>Kinetics of hydrate formation in sediments. Determination of gas and hydrate content of sediments saturated with hydrates. The effect of hydrate content on the properties of sediments.</td>
<td>1,5</td>
<td>1,5</td>
<td></td>
</tr>
<tr>
<td><strong>Properties of frozen and hydrated sediments</strong></td>
<td>Physical and thermal properties of frozen and hydrate saturated sediments. Changes in gas permeability, electrical and acoustic properties of sediments during hydrate and ice formation. Strength and deformation properties of hydrated and ice-containing sediments.</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Specific of the construction of production wells in the permafrost zone</strong></td>
<td>Zoning of territories of oil and gas provinces by the complexity of geocryological conditions for field development. Characteristics of engineering and geocryological studies for the selection of construction sites for producing wells. Complications arising from the construction and operation of permafrost wells.</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>The reaction of permafrost and gas hydrate accumulations in the permafrost zone under global climate change and industrial impacts</strong></td>
<td>Thermal and mechanical interaction of production wells with permafrost. The behavior of gas hydrate accumulations in frozen strata during the development of gas and oil fields in the Arctic. The impact of global climate change on the stability of wells and surface engineering structures of the oil and gas complex.</td>
<td>3</td>
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</tbody>
</table>

### 3. Assignments
<table>
<thead>
<tr>
<th>Assignment Type</th>
<th>Assignment Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>Short essay on the topics of lectures (for exm.&quot;Component and phase composition of frozen sediments&quot;)</td>
</tr>
<tr>
<td>Final Project</td>
<td>Oral presentation and report on the chosen topic</td>
</tr>
<tr>
<td>Test/Quiz</td>
<td>Short test on the lecture material (11 question)</td>
</tr>
<tr>
<td>Other</td>
<td>Exam on all learned material. Consists of 5 questions, where student should give full answer in written form</td>
</tr>
<tr>
<td>Other</td>
<td>Attendance, which will be marked on each lecture</td>
</tr>
</tbody>
</table>

### 4. Grading

<table>
<thead>
<tr>
<th>Type of Assessment</th>
<th>Graded</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Grade Structure</th>
<th>Activity Type</th>
<th>Activity weight, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Exam</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Final Project</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Attendance</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Homework Assignments</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Test/Quiz</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

### Grading Scale

<table>
<thead>
<tr>
<th>Letter</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>86</td>
</tr>
<tr>
<td>B</td>
<td>71</td>
</tr>
<tr>
<td>C</td>
<td>61</td>
</tr>
<tr>
<td>D</td>
<td>56</td>
</tr>
<tr>
<td>E</td>
<td>50</td>
</tr>
<tr>
<td>F</td>
<td>0</td>
</tr>
</tbody>
</table>

**Attendance Requirements**: Mandatory with Exceptions

### 5. Basic Information

| Course Stream | Science, Technology and Engineering (STE) |
Term 2

Every year

Masters Programs

| Petroleum Engineering |

PhD Programs

| Petroleum Engineering |

Engineering

6. Textbooks and Internet Resources

<table>
<thead>
<tr>
<th>Required Textbooks</th>
<th>ISBN-13 (or ISBN-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. D. Yershov, Edited by Peter J. Williams. General Geocryology. - CAMBRIDGE UNIVERSITY PRESS, 2004</td>
<td>9780521607575</td>
</tr>
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</table>

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

<table>
<thead>
<tr>
<th>Papers</th>
<th>DOI or URL</th>
</tr>
</thead>
</table>

7. Facilities

<table>
<thead>
<tr>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>classroom, projector, computer (labtop), clicker</td>
</tr>
</tbody>
</table>
8. Learning Outcomes

**Knowledge**

The nature of the Earth’s thermal field, the conditions for the permafrost formation, the features of the composition, structure and properties of frozen sediments, the main cryogenic processes and phenomena, to have an idea of the dynamics of frozen strata during the development of hydrocarbon deposits in the areas of permafrost distribution; the composition, genesis and existence of gas component in permafrost, the conditions for the formation and existence of gas hydrates in frozen strata and permafrost horizons, the processes of formation and decomposition of gas hydrates in sediments, the behavior of gas hydrates in permafrost during the development of oil and gas fields.

**Skill**

To assess the possibility of formation and degradation of frozen strata, to estimate the possibility of developing negative geocryological processes during hydrocarbon recovery in permafrost, assess the gas and hydrate content of sediments, analyze the processes of formation and decomposition of gas hydrates in the frozen sediments, assess the possible gas emission during decomposition of hydrate saturated sediments.

**Experience**

Students will experience the main methods of laboratory research of the phase composition and physical properties of frozen sediments, methods for assessing the gas and hydrate content of sediments, laboratory methods for studying the formation and decomposition of gas hydrates in sediments.

9. Assessment Criteria

**Input or Upload Example(s) of Assignment 1:**

- **Select Assignment 1 Type**
  - Homework Assignments

- **Input Example(s) of Assignment 1 (preferable)**
  - Please, prepare an essay (about 500-600 words, excluding reference list) about “Component and phase composition of frozen sediments”

- **Assessment Criteria for Assignment 1**
  - Assignments will be graded by the following criteria: Content / Development, Organization, Research, Style, English, Resources, Timelines, Plagiarism, Overall
  - by the scale: Excellent (10 - 8), Good (8-6), Need Improvement (5-3), Unacceptable (2-0)
Input or Upload Example(s) of Assignment 2:

**Select Assignment 2 Type**
Final Project

**Input Example(s) of Assignment 2 (preferable)**
Please, prepare a presentation and a report on the chosen topic

**Assessment Criteria for Assignment 2**
Assignments will be graded by the following criteria: Content / Development, Organization, Research, Style, English, Resources, Timelines, Plagiarism, Overall by the scale: Excellent (10 - 8), Good (8-6), Need Improvement (5-3), Unacceptable (2-0)

Input or Upload Example(s) of Assignment 3:

**Select Assignment 3 Type**
Test/Quiz

**Input Example(s) of Assignment 3 (preferable)**
11 short questions on the material of lectures, which suppose to prepare students for the final exam and help them to understand gaps in knowledge.

**Or Upload Example(s) of Assignment 3**
https://ucarecdn.com/543cd4ba-9cce-4a24-890a-6123e898c0f6/

**Assessment Criteria for Assignment 3**
Completely correct answer=1 point
Half answered question=0.5 point
Wrong answer=0 point
Total possible points 11 points

Input or Upload Example(s) of Assignment 4:

**Select Assignment 4 Type**
Final Exam

**Input Example(s) of Assignment 4 (preferable)**
5 questions on the topics of lectures

**Or Upload Example(s) of Assignment 4**
https://ucarecdn.com/aa66a8ea-d0fa-4d82-888c-ac4d04760b6a/

**Assessment Criteria for Assignment 4**
Completely correct and full answer = 2 points
Answer with a minor mistake or not completely full = 1 point
Answer with some mistakes, but including the main idea and knowledge = 0.5 points
The answer contains a lot of mistakes without main point = 0 points
Maximum possible points - 10 points

Input or Upload Example(s) of Assignment 5:
<table>
<thead>
<tr>
<th><strong>Select Assignment 5 Type</strong></th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Example(s) of Assignment 5</strong></td>
<td>Attendance will be marked on each lecture and highly recommended for a full understanding of the course material</td>
</tr>
<tr>
<td><strong>Assessment Criteria for Assignment 5</strong></td>
<td>Attendance is weight 20% of total grade</td>
</tr>
</tbody>
</table>

**10. Additional Notes**