Course Title (in English): Structural analysis and Design
Course Title (in Russian): Анализ прочности и проектирование конструкций
Lead Instructor(s): Sergeichev, Ivan

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)

Contact Person: Ivan Sergeichev
Contact Person’s E-mail: i.sergeichev@skoltech.ru

1. Annotation

Course Description

The Structural analysis and Design course gives students basics of strength analysis and design of typical structural members. Theoretical sections include introductions into stress and strain theories, failure criteria, elasticity theory, nonlinear material behavior and analysis of tension, compression, bending and shear structural members. Students learn finite element software Abaqus and work on development of FE models and stress analysis of structural parts taking into account nonlinear material behaviour, mechanical and thermal interactions.

Course Prerequisites / Recommendations

Calculus, Differential Equations (ODE and PDE), Basics of Solid Mechanics, Material Selection in Mechanical Design.

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>Introduction to stress theory</td>
<td>Stress tensor, plane stress, stress transformations. Principal stresses and maximum shear stresses. Stress invariants.</td>
<td>2</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Failure criteria</td>
<td>Max principal stress criteria, Tresca/ maximum shear stress criterion, the von Mises yield criterion / distortional strain energy density criterion.</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Plane stress applications</td>
<td>Analysis of tubes, pressure vessels. Thick-wall cylinders, Lamé’s equations.</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Nonlinear material behavior</td>
<td>Ramberg-Osgood, Johnson-Cook stress-strain laws. Strain rate and temperature effects.</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>The basics of interacting with Abaqus/CAE</td>
<td>Model tree, modules and toolsets. Creation a simple FE model by Abaqus/CAE. Viewing results</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Assembling a FE model</td>
<td>Contact interactions. Constraints. Boundary conditions. Loads.</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>FE analysis of typical structural members</td>
<td>FE analysis of beam, frame and truss structural members.</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>FE modeling and analysis of plates and shells</td>
<td>Continuum shell modeling. Skin and stringer reinforcements</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Nonlinear static analysis</td>
<td>Nonlinear material behaviour, buckling prediction or beam and shell structures.</td>
<td></td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

### Assignments

3. Assignments
### Assignment Type

<table>
<thead>
<tr>
<th>Assignment Type</th>
<th>Assignment Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test/Quiz</td>
<td>Introduction to stress theory</td>
</tr>
<tr>
<td>Test/Quiz</td>
<td>Introduction to elasticity theory</td>
</tr>
<tr>
<td>Test/Quiz</td>
<td>Analysis of typical structural members</td>
</tr>
<tr>
<td>Project</td>
<td>Individual design project</td>
</tr>
<tr>
<td>Other</td>
<td>Final exam</td>
</tr>
<tr>
<td>Other</td>
<td>Homeworks</td>
</tr>
</tbody>
</table>

### 4. Grading

**Type of Assessment**

- Graded

**Grade Structure**

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Activity weight, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework Assignments</td>
<td>20</td>
</tr>
<tr>
<td>Test/Quiz</td>
<td>10</td>
</tr>
<tr>
<td>Test/Quiz</td>
<td>10</td>
</tr>
<tr>
<td>Test/Quiz</td>
<td>10</td>
</tr>
<tr>
<td>Final Exam</td>
<td>25</td>
</tr>
<tr>
<td>Projects</td>
<td>25</td>
</tr>
</tbody>
</table>

**Grading Scale**

- A: 85
- B: 75
- C: 65
- D: 55
- E: 45
- F: 0

**Attendance Requirements**

- Mandatory with Exceptions

### 5. Basic Information

**Maximum Number of Students**
### Maximum Number of Students

<table>
<thead>
<tr>
<th>Overall</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Group (for seminars and labs):</td>
<td>5</td>
</tr>
</tbody>
</table>

### Course Stream

Science, Technology and Engineering (STE)

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

Term 2

### 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>Energy Systems</td>
<td>Engineering Systems</td>
</tr>
<tr>
<td>Materials Science</td>
<td>Materials Science and Engineering</td>
</tr>
<tr>
<td>Mathematical and Theoretical Physics</td>
<td>Mathematics and Mechanics</td>
</tr>
<tr>
<td>Petroleum Engineering</td>
<td>Petroleum Engineering</td>
</tr>
<tr>
<td></td>
<td>Physics</td>
</tr>
</tbody>
</table>

**Course Tags**

Math  
Engineering  
Mechanics

### 6. Textbooks and Internet Resources

**Required Textbooks**


**Recommended Textbooks**


### 7. Facilities
8. Learning Outcomes

**Knowledge**
- Principal basic knowledge in the structural design process, concepts and philosophies.
- Stress theory, failure criteria, material models.
- Basics of finite element modeling and Abaqus software.

**Skill**
- Development and analysis of finite element models of typical structures.
- Application of theoretical material models to structural analysis and design.
- Design and analysis of typical structural members.

**Experience**
- Theoretical and finite element analysis of structures.
- Design process.

9. Assessment Criteria

Input or Upload Example(s) of Assignment 1:

**Select Assignment 1 Type**
- Test/Quiz

**Or Upload Example(s) of Assignment 1**
- https://ucarecdn.com/b693edc9-8451-4b2d-8a83-2bc5849ec72f/

**Assessment Criteria for Assignment 1**
- 10 - four problems solved correctly and written clear;
- 9 - four problems solved correctly but there are some inaccuracies for written representation of solutions;
- 8 - three problems solved correctly and written clear;
- 7 - three problems solved correctly and there are some inaccuracies for written representation of solutions;
- 6 - two problems solved correctly and written clear;
- 5 - two problems solved correctly and there are some inaccuracies for written representation of solutions;
- 4 - one problem solved correctly and written clear;
- 3 - one problem solved correctly and there are some inaccuracies for written representation of solutions;
- 2 - no problem solved correctly;
- 0 - the quiz has not been attended without legal reason.
### Assessment Criteria for Assignment 2

- **25** - four problems solved correctly and written clear;
- **21-24** - four problems solved correctly but there are some inaccuracies for written representation of solutions;
- **20** - three problems solved correctly and written clear;
- **16-19** - three problems solved correctly and there are some inaccuracies for written representation of solutions;
- **15** - two problems solved correctly and written clear;
- **11-14** - two problems solved correctly and there are some inaccuracies for written representation of solutions;
- **10** - one problem solved correctly and written clear;
- **6-9** - one problem solved correctly and there are some inaccuracies for written representation of solutions;
- **5** - no problem solved correctly;
- **0** - the exam has not been attended without legal reason.

### Assessment Criteria for Assignment 3

- **25** - excellent presentation of the project highlighting a problem statement and a solution with good answering questions;
- **21-24** - good presentation of the project highlighting a problem statement and a solution but there are some insignificant inaccuracies/mistakes, correct answering questions;
- **16-20** - presentation of the project with missing meaningful parts and/or results, correct answering questions;
- **10-15** - outline of the project and results partly presented with week answering questions;
- **0** - no project presented;

### Assessment Criteria for Assignment 4

- **Homework Assignments**
- **Homework assignment**
### Assessment Criteria for Assignment 4

+ a homework problem is solved correctly  
- a homework problem is not solved correctly  

Homework assessment is summarized as a part of 20% of activity weight of total assessment (see section 4) as \( S/T \times 20\% \), where \( T \) is a total number of homework problems for the course, \( S \) is a number of the correctly solved problems (number of +).

### Input or Upload Example(s) of Assignment 5:

### 10. Additional Notes