Course Title (in English) | Fundamentals of Power Systems
---|---
Course Title (in Russian) | Основы энергетических систем
Lead Instructor(s) | Pozo Camara, David

Status of this Syllabus | The syllabus is a final draft waiting for form approval
Contact Person | David Pozo
Contact Person’s E-mail | d.pozo@skoltech.ru

1. Annotation

Course Description | This course covers power systems analysis & operations, including fundamentals (balanced three-phase power) steady-state analysis (power flow), state estimation, operation (optimal power flow), security (contingency analysis and security-constrained optimal power flow), distribution grid operation, and challenges and trend of future power systems. After successfully completing this course, the student will be capable of analyzing the technical and economic operation of an electric energy system.

Course Prerequisites | Students should have basic knowledge of Algebra, Electric Circuits and be familiar with Operation Research and Programming.

2. Structure and Content

Course Academic Level | Master-level
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 and basis for power systems components</td>
<td>How power systems are and how they work, balanced three-phase power, power system structure. Modeling generators, transformers, load and electric lines</td>
<td>6</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Power System steady-state analysis</td>
<td>Power flow equations, Newton-Raphson solution, DC power flow, Decoupled power flow.</td>
<td>6</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Power system state estimation</td>
<td>Observability, estimation, bad data detection and identification</td>
<td>6</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Power system operations security</td>
<td>Contingency analysis, optimal power flow, security constrained optimal power flow</td>
<td>6</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Distribution grids</td>
<td>Optimal power flow for grids, DistFlow and LinDistFlow.</td>
<td>6</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Challenges and future trends in power systems</td>
<td>Demand-response technologies. Renewable generation challenges. Integration of wind and solar power, reduced inertia of power systems. Energy storage. Integrated energy systems.</td>
<td>6</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

3. Assignments

<table>
<thead>
<tr>
<th>Assignment Type</th>
<th>Assignment Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>Basics on power components and theory of circuits</td>
</tr>
<tr>
<td>Homework</td>
<td>Power flow</td>
</tr>
<tr>
<td>Homework</td>
<td>State estimation</td>
</tr>
<tr>
<td>Homework</td>
<td>Security-constrained OPF</td>
</tr>
<tr>
<td>Homework</td>
<td>OPF over distribution grids</td>
</tr>
<tr>
<td>Project</td>
<td>Final project</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></td>
<td>Homework Assignments</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Final Project</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Final Exam</td>
<td>40</td>
</tr>
</tbody>
</table>

A: 86
B: 76
5. Basic Information

**Attendance Requirements**
Mandatory

**Course Stream**
Science, Technology and Engineering (STE)

**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>Energy Systems</td>
<td></td>
</tr>
</tbody>
</table>

**Course Tags**
Math
Physics
Programming
Engineering

6. Textbooks and Internet Resources

**Required Textbooks**


**Recommended Textbooks**


**Web-resources (links)**

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PowerWorld</td>
</tr>
<tr>
<td>Julia Language</td>
</tr>
</tbody>
</table>

7. Facilities

**Software**

- Julia
- PowerWorld

8. Learning Outcomes
## Knowledge

- How modern power systems and their main components work
- How power systems is operated in steady-state,
- How to estimate the state of a power system,
- How to perform a security analysis of a power system,

## Skill

- Applying knowledge of mathematics, science, and engineering to power systems
- Designing and conducting computational experiments, as well as to analyze and interpret data.
- Identifying, formulating, and solving electric power system problems.
- Knowledge of contemporary issues on power systems

## Experience

- Ability to work with research literature on power systems.
- Ability to work in team on complex projects with work sharing based on the topic.

---

### Do you want to specify outcomes in another framework?

Knowledge-Skill-Experience is good enough

### 9. Assessment Criteria

#### Select Assignment 1 Type

- Homework

#### Input Example(s) of Assignment 1 (preferable)

Assessment criteria for Homework

#### Or Upload Example(s) of Assignment 1

https://ucarecdn.com/39debd9c-c16f-481c-b17c-7f5eb6e48e96/

#### Assessment Criteria for Assignment 1

**Scoring ---**

The maximum number of points for each homework is 100. Student receive points based on the results of homework. Each homework has the same contribution to the final grade. If the homework is not done, it means 0 points.

**Timing ---**

Each homework is given after theory and there is one week for accomplishing it. Dates are notified to the students.

**Penalizations ---**

There is a penalization of -10 points for every hour of homework submission delay after its deadline.

There are strong penalizations on partial or total plagiarism. Not only in the homework, but also for the rest of the course.

#### Select Assignment 2 Type

Team Project

#### Input Example(s) of Assignment 2 (preferable)

Assessment criteria for Final Project
### Assessment Criteria for Assignment 2

**General ---**
Every team of 2-3 persons should choose a project and develop it until the end of the course. The project will finish with a final report and a final presentation.

**Scoring ---**
The maximum number of points for the project report and presentation is 100. The final report represents 50% of the total score. The other 50% is from the final presentation. Any student can be asked to defend any part of the final project (avoid divide and paste practices). Every student from the same team would receive the same grade that his teammates with some exceptions (see below penalizations).

**Timing ---**
At the end of the second week of the course, the students should have a team and topic for the project. There will be a list of topics to work with, but each team could propose its own topic.

Every week, each team should report on the advances of the project to the TA/Professor. It is a good moment to ask questions.

**Penalizations ---**
There is a penalization of -10 points for every hour of final project submission delay after its deadline.

Every student must be at the final presentation.

There are strong penalizations on partial or total plagiarism.

If a student does not collaborate with the team tasks, he/she could receive a lower grade while his/her teammates would increase theirs.

---

### Select Assignment 3 Type

Other

### Input Example(s) of Assignment 3 (preferable)

The challenge problem

### Or Upload Example(s) of Assignment 3

https://ucarecdn.com/0bcf81e2-a5c8-418e-bccb-4eec8ba1dfe9/

### Assessment Criteria for Assignment 3

There will be an optional “challenge problem” that can increase the overall final grade of the student. It is individual. It does not penalize. The challenge problem will be announced at the end of the second week of the course. The deadline will be close to the final project report submission. Every student that submits “the challenge problem” can obtain from 0 to 100 points. Its challenge problem is worth 10% over the final grade.

---

### Select Assignment 4 Type

Other

### Input Example(s) of Assignment 4 (preferable)

Final grade according to the assessments

### Assessment Criteria for Assignment 4

As a summary, the final grade will be computed

a) Final exam [0-40] points
b) Final project (report + presentation) [0-30] points
c) Homework assignments [0-30] points
d) “The challenge problem” [0-10] points

Pass the course if: \((a + b + c \geq 50) \& \ (a \geq 20) \& \ (b + c \geq 30)\)

Final grade = \(\min (a + b + c + d, 100)\)

---

10. Additional Notes
<table>
<thead>
<tr>
<th>Web-resources (links)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="https://www.powerworld.com/">https://www.powerworld.com/</a></td>
<td>PowerWorld</td>
</tr>
<tr>
<td><a href="https://julialang.org/">https://julialang.org/</a></td>
<td>Julia Language</td>
</tr>
</tbody>
</table>