# EE 553 Steady-State Analysis

Fall 2023
Department of Electrical and Computer Engineering
Iowa State University

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| **Instructor** | Bai Cui |
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| **Email** | baicui@iastate.edu |
| **Office Hours** | M/W 4–5, or by appointment |
| **Class Time** | T/Th 11:00–12:15 |
| **Location** | Hoover Hall 1322 |

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**Course Pages** All course content such as announcements, slides, homework, grades and other required reading will be made available on Canvas.

**Course Prerequisite** Familiarity with power system analysis methods. Familiarity with the following topics is essential: linear and matrix algebra, network analysis theory including electric power flow analysis, and basic optimization concepts.

**Textbook** We will more or less follow the following book:

- A. J. Wood, B. F. Wollenberg, and G. B. Sheblé, *Power Generation, Operation, and Control*, Wiley, 3rd Ed., 2014.

However, the course material will be posted online, so the textbook is not mandatory.

There are several other good references on power system analysis:

1. J. D. Glover, T. J. Overbye, M. S. Sarma, and A. B. Birchfield, *Power System Analysis and Design*, Cengage Learning, 7th Ed., 2022.

2. J. Grainger and W. Stevenson, *Power System Analysis*, McGraw Hill, 1994.

3. A. Bergen and V. Vittal, *Power Systems Analysis*, Pearson, 2en Ed., 1999.

If you've never taken power system analysis courses (at the level of EE 303 or EE 456) before, it is highly recommended that you read one of the books above.

The course is heavier on optimization than a typical power courses, some good references on optimization are the following:

- D. Bertsimas and J. N. Tsitsiklis, *Introduction to Linear Optimization*, Athena Scientific, 1997.

- R. Baldick, *Applied Optimization: Formulation and Algorithms for Engineering Systems*, Cambridge University Press, 2006.

**Tentative Course Schedule** The schedule below is tentative. Adjustments may be made as the course proceeds. (Lecture $w.d$ refers to the Lecture on day $d$ in week $w$, where $d = 1$ (resp., 2) refers to Tuesday (resp., Thursday). For example, Lecture 1.1 refers to Tuesday's Lecture in week 1.)

Lecture 1.1 ........ Course Overview and Introduction

Lecture 1.2 ........ Power Flow
Modeling, problem formulation.

Lecture 2.1 ........ Power Flow
Matrix analysis, algorithms.

Lecture 2.2 ........ Power System Security
Contingency analysis, network sensitivity matrices.

Lecture 3.1 ........ Power System Security
Steady-state stability.

Lecture 3.2 ........ Electricity Market
Industrial organization and managerial economics.

Lecture 4.1 ........ Economic Dispatch
Characteristics of power generation units.

Lecture 4.2 ........ Economic Dispatch
Modeling and problem formulation.

Lecture 5.1 ........ Economic Dispatch
Solution methods (simplex, interior-point method, . . . ).

Lecture 5.2 ........ Economic Dispatch
Locational marginal price, auction mechanisms.

Lecture 6.1 ........ No Class
Midterm I.

Lecture 6.2 ........ Optimal Power Flow
Problem formulation.

Lecture 7.1 ........ Optimal Power Flow
Solution methods.

Lecture 7.2 ........ Optimal Power Flow
Security-constrained optimal power flow.

Lecture 8.1 ........ Unit Commitment
Problem formulation.

Lecture 8.2 ........ Unit Commitment
Solution methods (Lagrangian relaxation, dynamic programming, mixed-integer programming, . . . ).

Lecture 9.1 ........ Unit Commitment
Security-constrained unit commitment.

Lecture 9.2 ........ State Estimation
Modeling, problem formulation.

Lecture 10.1 ........ State Estimation
Solution algorithm.

Lecture 10.2 ........ Fuel Scheduling

Problem formulation and solution method.

Lecture 11.1 ........ Hydro-Thermal Coordination
Modeling, problem formulation.

Lecture 11.2 ........ Hydro-Thermal Coordination
Solution methods.

Lecture 12.1 ........ No Class
Midterm II.

Lecture 12.2 ........ Hydro-Thermal Scheduling
Modeling, problem formulation.

Lecture 13.1 ........ Hydro-Thermal Scheduling
Solution methods.

Lecture 13.2 ........ Automatic Generation Control
TBD.

Lecture 14.1 ........ No Class
Thanksgiving Holiday.

Lecture 14.2 ........ No Class
Thanksgiving Holiday.

Lecture 15.1 ........ Emerging Topics
TBD.

Lecture 15.2 ........ Emerging Topics
TBD.

Lecture 16.1 ........ No Class
Prep Week.

Lecture 16.2 ........ No Class
Prep Week.

Week 17 ........ No Class
Final Exam.

Time permits, we will discuss some emerging topics such as DER integration and market operation under uncertainty.

**Exams** There will be two 75-minute exams during the semester and a comprehensive final exam. No make-up exams will be given, unless there is a legitimate reason for missing the exam that is not under the student's control, and the student makes appropriate arrangement with the instructor in advance of the scheduled exam.

**Assignments** Besides two midterms and the final exam, there will be two different types of assignments.

- **Homework problems**: I will assign some homework problems to help you consider more deeply some of the material we covered in class. Solutions to the problems will be made available to you on Canvas.
- **Project**: There will be an exploratory course project. Basic programming knowledge is required.

**Grading Policy** Three components determine your grade: Exams, Homework and Project. The relative weights are as follows:

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| Midterm I | 15% |
| Midterm II | 15% |
| Final Exam | 20% |
| Project | 20% |
| Homework | 30% |

You are guaranteed to receive at least the letter grades determined by the guidelines below:

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| 90 and above | A |
| 80 – 89 | A-/B+/B |
| 70 – 79 | B-/C+/C |
| 60 – 69 | C-/D+/D |
| 60 and below | D-/F |

**Course Objectives** At completion of this course, students should be able to

- Write a power flow program using sparse matrix techniques.
- Articulate power system security criteria and implement security assessment techniques.
- Compute economic characteristics of thermal power generation units.
- Perform economic dispatch calculations.
- Communicate the problem structure and solution approach for the optimal power flow and the security-constrained optimal power flow (SCOPF).
- Communicate the problem structure and solution approach for the unit commitment and the security-constrained unit commitment (SCUC).
- Identify how SCOPF and SCUC are used in today's electricity markets.
- Implement least squares method of performing state estimation.
- Specify strengths and weaknesses of various optimization methods used to solve the different problems discussed in this course.