ERC Starting Grant
Past Experience and Perspectives

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Head of Section Power Systems
Associate Professor, DTU

A few words about my background

- Associate Professor at DTU
- Head of Section Power Systems (team of ~30 persons; 6 senior faculty)
  [Assistant Prof. DTU 2016-2018]

- PhD from ETH Zurich, Switzerland (2013)
  [BSc/MSc from National Tech. Univ. Athens, Greece 2007]

- Postdoc at MIT (2015-2016)
- Postdoc at Lawrence Berkeley National Lab (2014-2015)

- **Thinking about applying to ERC since 2016… got it in 2020**
  - inspired by my Group Leader/Section Head at the time
- Did not apply in 2017
  - A lot of other commitments: large new project was starting; new teaching starting
  - Did not have a strong idea yet; only knew that I wanted to do AI/Deep Learning for Power Systems
- Applied in 2018 (second last chance; passed the first stage; failed)
- Applied in 2019 (last chance; got it ☺)
  - First ERC at DTU Elektro

A few words about my field

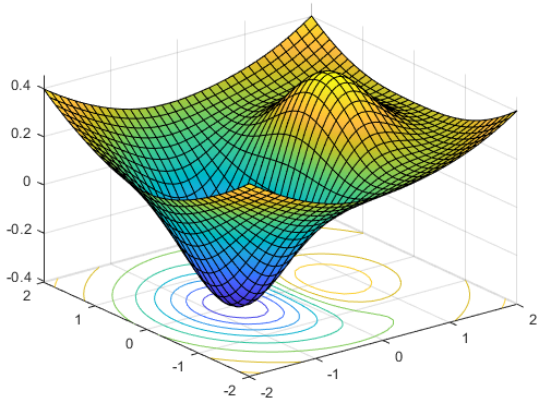
- **Electric Power Grids; purely computational**

- Main questions are about:
  - How can I predict a blackout faster and avoid it?
  - How can I minimize the cost of energy?

- **Falls in the general field of non-linear dynamic systems**

- **In summary: a very "abstract" field that is difficult to explain; nothing tangible (e.g. like building a new device); <u>but</u> electricity affects us all and everyday**
- Only 3 persons have received an ERC StG in our field (2018, 2019, 2020; none had, when I started thinking to apply)

- **Question: what can I propose that can convince them that it is truly groundbreaking?** And to a panel where most of them are not experts in power systems



Main takeaways
from my experience during the ERC application journey

Start (applying) early!

- You should start applying while having at least 3-4 years in front of you
  - Majority of ERC Grantees do not get it the first time
  - If you do not pass in the second round, you are banned for a year → you need to apply 3 years in advance to have a second chance
  - **Even if you fail, the comments of the ERC reviewers, esp. if you pass in the second round, are extremely helpful**
    - You understand deeper which parts of your idea are the most important → focus on them next time you apply

- Disclaimer: I did not do that. In 2017, I did not feel I had a strong idea, and did not want to risk getting a "C" →would be banned for two years; no more chances left.

- But if I were to do it again, I would have started thinking about the ERC as early as possible.

No idea is too crazy!

- **To get an ERC, we need to think different**. We are not talking about incremental improvements; we are talking about something groundbreaking. **How do I find such an idea?**

1. Let your mind free

A possible path

2. "Envision" the future → how do you think the future in your field will look like?

3. Identify the barriers that "obstruct" the realization of such a future

4. **Get inspired from other fields → <u>discuss</u> with friends/colleagues, look into the literature**
   - Did they have similar problems? What solutions did they propose?

5. Are these ideas/solutions applicable in your field?

6. How can you move even a step beyond these ideas and develop a solution/tool/understanding that will be helpful in many other fields too?

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1. "If everybody agrees, it is not new."

My path

2. Millions of devices, big data, high speed → AI is coming to power systems (as in hundreds of other fields…!); indeed, lots of papers.

3. Power systems = safety-critical systems → <u>nobody in the industry trusts AI</u>;

4. Robots and self-driving cars = safety-critical systems → Researchers develop AI verification (i.e. now called trustworthy AI)

5. Neural network verification can apply to power systems!

6. Further extended these ideas; proposed "groundbreaking" methods for other fields too

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My actual path

1. Step #4 came before #3 → first realized what is possible in other fields, and then thought 1)it is important that we also develop that in our field, 2) moved the idea a few steps further.

2. Although my first application had some strong elements, the positioning of my proposal was around deep learning

3. I received a lot of (harsh but fair) criticism about deep learning

4. And praise about the AI verification part → changed my proposal the second time

5. Not sure if the potential of your idea to be applied in other fields is so important; but it is certainly welcome. It means that your idea is fundamental.

Work on your idea!

- I was lucky to already have 5 PhD students at the time I was submitting my ERC application (due to grants that were irrelevant to my ERC topic)
- After submitting my first ERC proposal, I pitched the idea to some of them:
  - 2-3 of them were interested but they also had other commitments due to the projects
- What did we do?
  1. We created Master thesis proposals to get MSc students work on that
  2. The only student I had on a full DTU scholarship decided to work full-time on that
  3. The other two students that were on project funding, worked part time
- By the second time I applied, we had submitted two journal papers (in prestigious journals), 1 conference paper, and had a lot more knowledge about what can go wrong with the ideas contained in the proposal → I was able to write a much stronger section about feasibility and risks
- What can you do? Try to obtain funding from DTU to dedicate time to work on your idea

The interview

- Had 32 versions
- Went to the seminar in Holland
- A lot of dry-runs with people I trusted, including Johannes, and a former PE7 member

Wrap-up

1. Start (applying) early

2. No idea is too crazy
   - Fundamental research
   - Looking for groundbreaking ideas

3. Work on your idea!

4. Get feedback from people you trust

Thank you!

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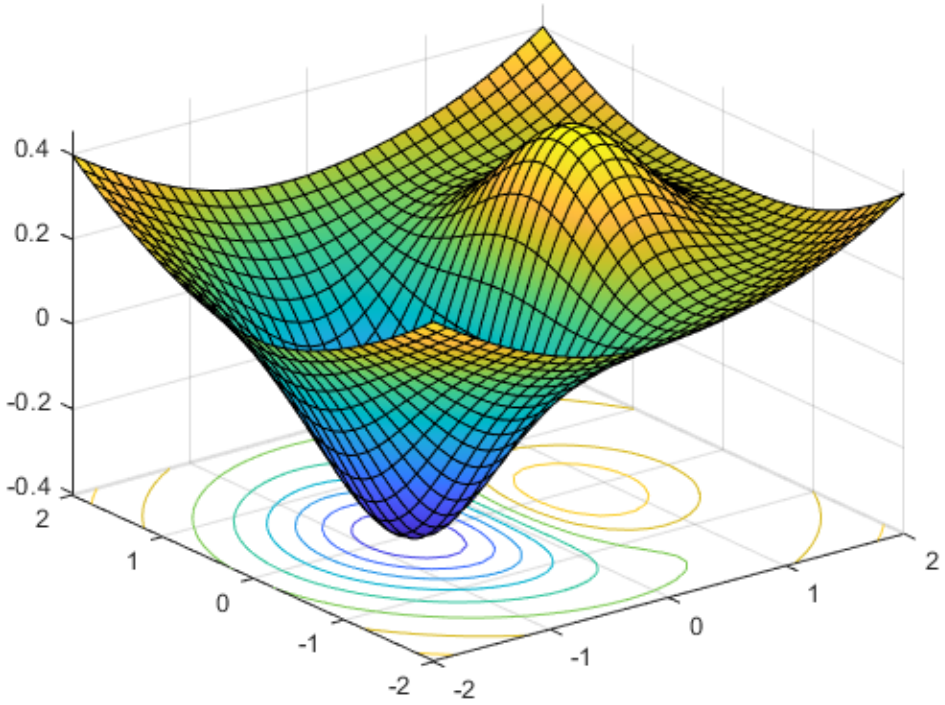
Details about the course

- 31765: Optimization in modern power systems
- 5 ECTS; Lectures take place once a week
- 2-hour lecture and 2 hours working on their assignments
  - Sometimes more lecture than assignments, if necessary
- About 40 students
- 3 assignments:
  - 3-4 weeks to deliver each
  - 2-4 persons per group (ideally 3)

Course Content

- ✓Optimal Power Flow and Electricity Markets
- ✓Linear and Non-linear Optimization (DC-OPF, AC-OPF)
- ✓Convex functions
- ✓Semidefinite Optimization (and OPF)
- ✓KKTs, Lagrangian, Duality

- Substantial amount of theory
- And substantial amount of coding in Matlab or Python
- Some of the concepts are difficult



Main takeaways
from my experience teaching this class the past 4 years

--- some of the following practices are because of the knowledge gained from UDTU! ---

1. Learning their names

- Creates a more personal atmosphere in the class
  - **Students participate more**; not afraid to ask questions

- **Students appreciate it →**
  - they are more motivated
  - and (probably subconsciously) they wouldn't want to feel embarrassed if they cannot answer a question → they pay more attention

- Impossible to learn all names at once (trick similar to Jalal :))
  - Learn as many names as I can, and call these students by name
  - Gradually learn the rest of the names

2. Is this clear?

- Eyes give out the most reliable signs
- Always maintaining eye contact with the students
- If there is a feeling that people do not follow:

“Is this clear? Shall I say it again?”

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“Is this clear? Shall I say it again?”

I really appreciated how the instructor was willing to reexplain concepts so that students could get a better handle on them.

Very good explanation of the subject. Learnt a lot during the course

Good explanations and very clear in the examples. However sometimes spend too much time on basic stuff and I think people don't participate because they stop listening more than because they don't get it. (But I am not sure).

3. Repetitio mater studiorum est

«Επανάληψις μήτηρ πάσης μαθήσεως εστίν»

Ancient Greek proverb

Repetition is the mother of all learning

In every lecture:

- For 5 minutes discuss with the person sitting next to you about:
  - Three main points we discussed in the last lecture
  - One topic or concept that is not so clear to you and you would like to hear again about it

3. Repetition is the mother of all learning

1. Students **more comfortable to discuss among them** anything they did not understand from the last lecture

2. **Good warm-up** (class starts at 8.30am!) and **smooth connection** between previous and current lecture
   - Lectures take place once a week

3. Students can **"digest"** what we discussed in the previous lecture and come back with **better questions**

4. This discussion can last 10 mins or **up to 40 minutes**!
   - Have to plan for this in my available "lecture time"
   - Despite being sometimes long, it is very useful for the students, so that they keep up with the new concepts introduced in every lecture

5. Students really like it!

- For 5 minutes discuss with the person sitting next to you about:
  - Three main points we discussed in the last lecture
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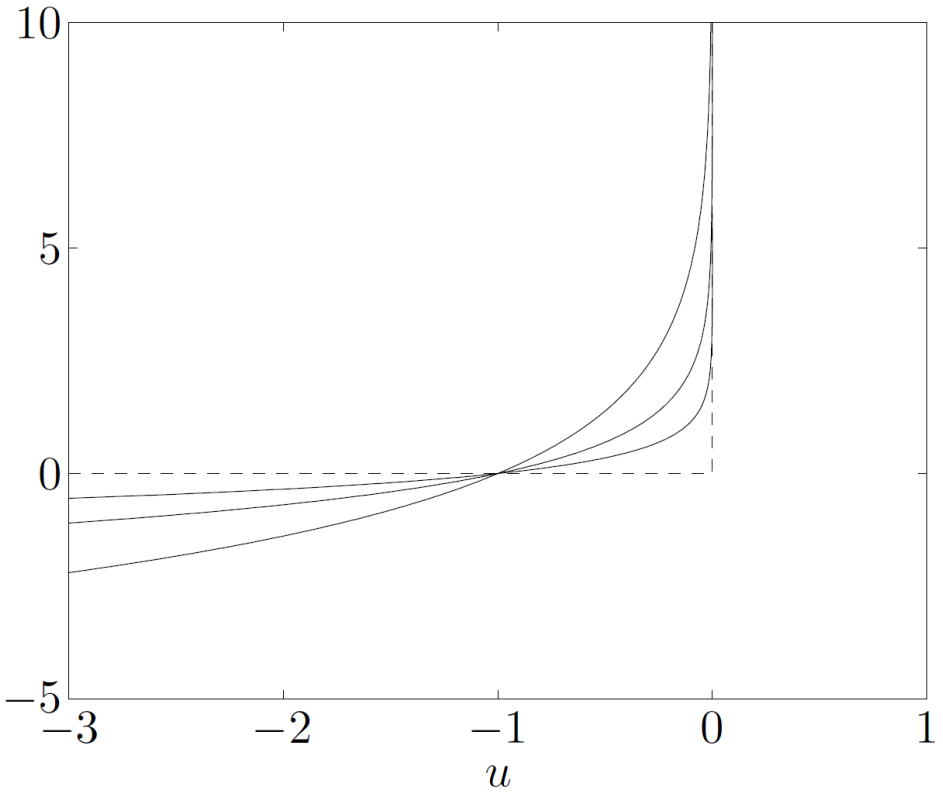
Great the recap at the beginning of the class. Really helpful

Every lecture before beginning the new session we are reviewing what we did last time which is a really good thing to be sure that everyone is able to follow.

4. “Lecturer for a day”

- **Challenge:**
  - I want the students to understand how the optimization solvers work from the inside (and not use them as a black box)



Log-barrier function to approximate inequality constraints

(used in interior-point method)

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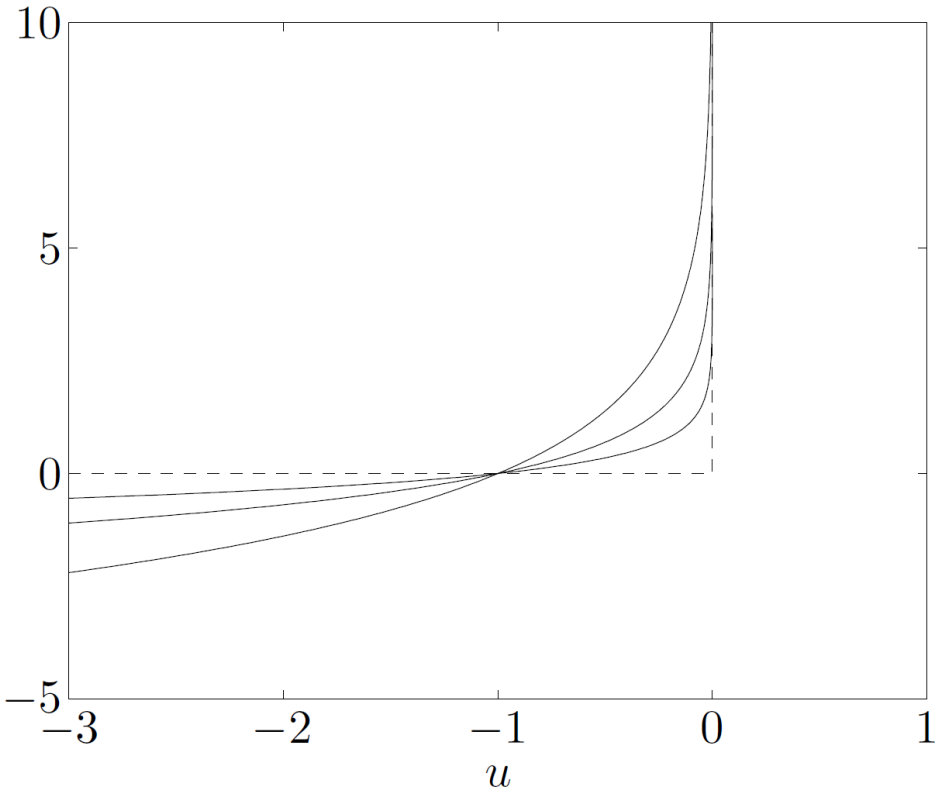
  - **Why?**
    i. they can formulate their optimization problem in a more suitable way for the solver,
    ii. they can understand what the error messages and the log file mean



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  - **Why?**
    i. they can formulate their optimization problem in a more suitable way for the solver,
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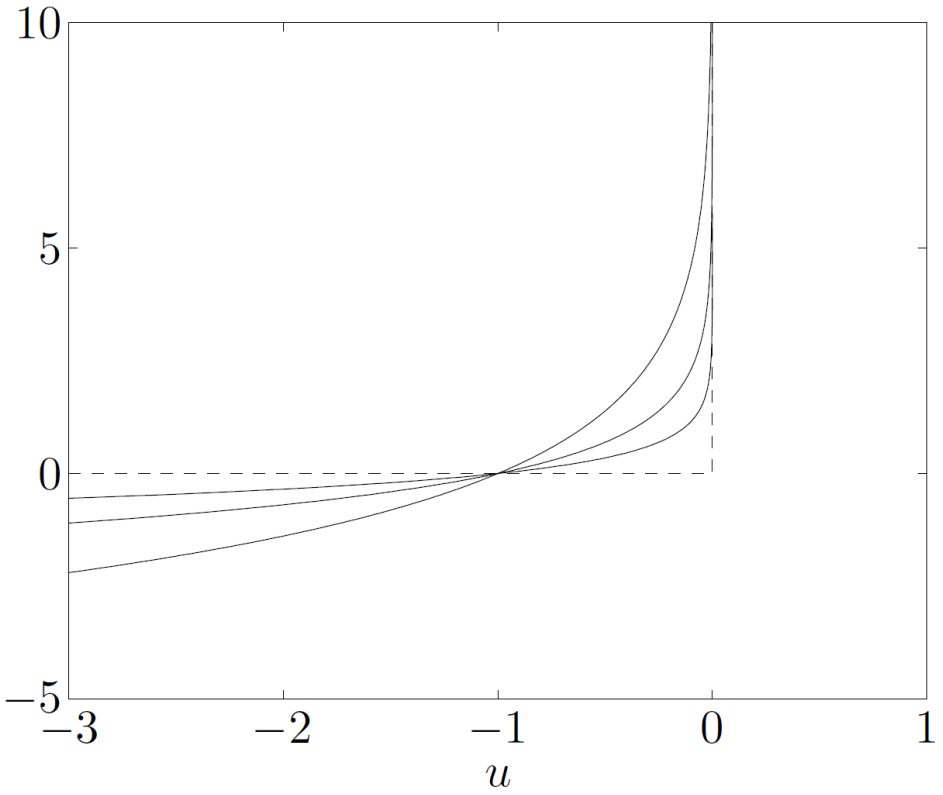
- **But:**
  - Solution methods (e.g. interior-point method) are very complex to explain in 1 lecture
  - Even more difficult, when **I have only 1 lecture to explain 4 such methods**

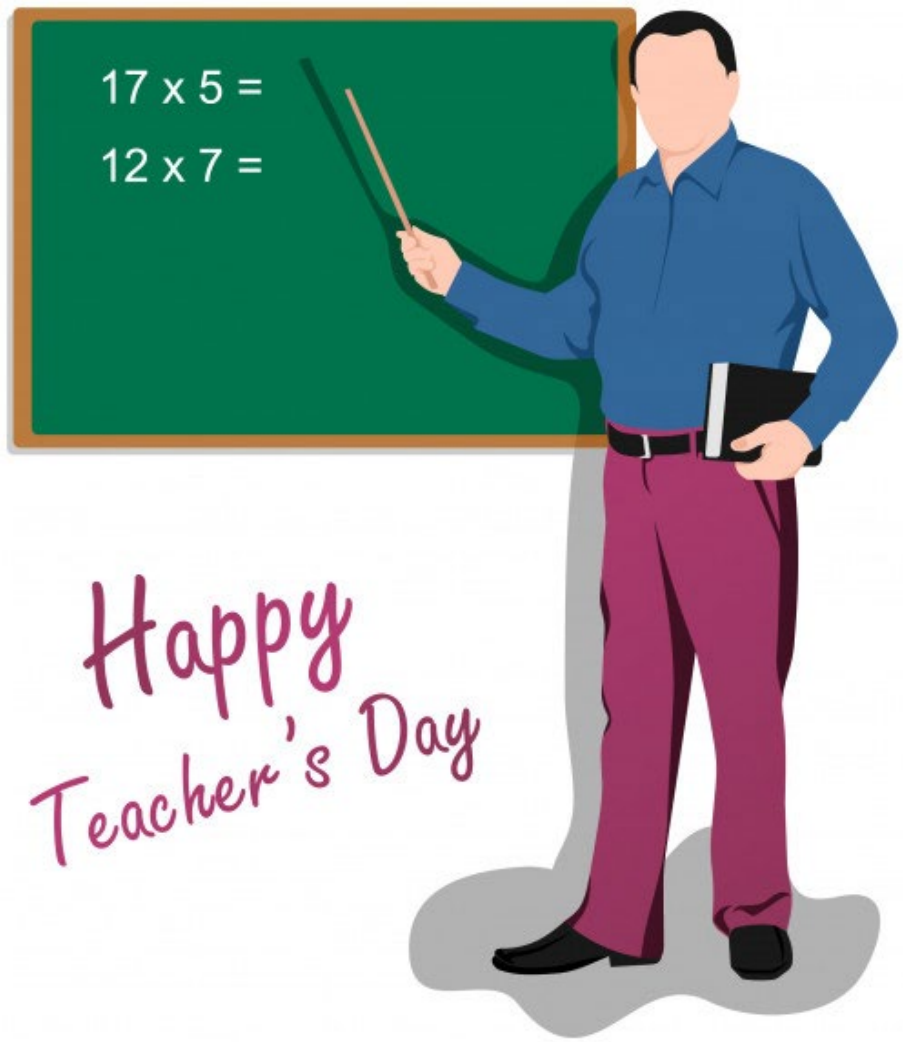


What do I do?

4. Lecturer for a Day

- Solution:
  - **Make the students study a method, and "teach" it to the rest of the class**

- **Assignment (3-4 weeks to deliver)**
  1. Each group picks a topic
  2. They prepare a 20-min presentation
  3. Each presentation receives feedback from a peer-review group
  4. The students "teach" the rest of the class, i.e. present their topic as if they are lecturers
  5. Each group receives a lecturer evaluation by the rest of the class



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- **Peer-review process**
  1. There are usually 10-14 groups
  2. Students pick their two "favorite" topics: a topic to present and a topic to peer-review
  3. Peer-review=learn to give constructive feedback
  4. Two groups sit together for at least 1 hour, go through the presentation and receive feedback
     a. This **improves the quality of the presentation** for the rest of the class
     b. Each group learns well at least two topics (what they present+peer-review)
     c. Learn to give feedback

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- **Evaluation of each lecture by the class**

Topic #3: Interior-point method

1. I think I learnt a lot from this lecture:
2. I think the presentation material was good:
3. I think the teachers are good at communicating the subject:

- Each group understands how challenging is to teach well a subject
- They receive feedback

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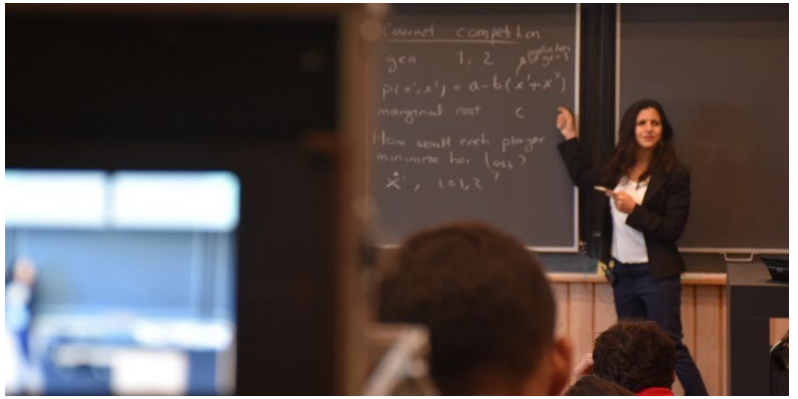
I bring Christmas Cookies!

- with the "excuse": I did not need to prepare a lecture for today, so I had time to bake (or buy) cookies ☺
- It makes the atmosphere a bit more relaxed; and it is also a sign of appreciation for their hard work during the semester

5. Being (well) prepared

- **Students appreciate simple and specific explanations**
- **Losing our confidence**, being too abstract, or too complex → **students directly understand** that we are not sure
- **Maintaining confidence = being well prepared**
- While preparing the lecture material and slides:
  - How can I explain this in the **simplest possible way**?
  - For every single step: why?
  - Example: $Z=R+jX=R+j\omega L$ → why?
- Of course, not always possible to know all the answers
  - **"I will look into it and get back to in the next lecture/by email"**.
- Writing Lecture Notes → helps clarify (to us) many things



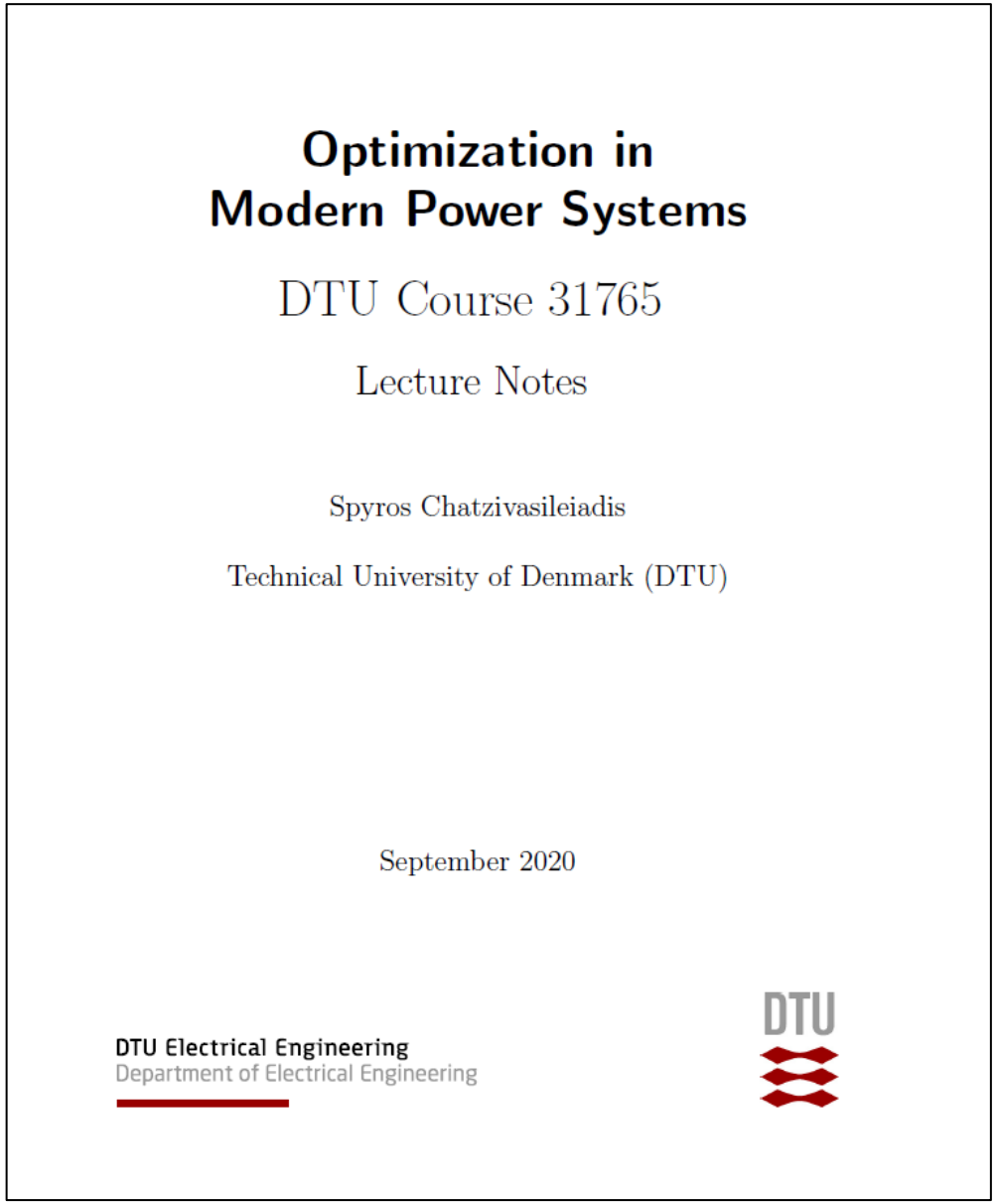
The content delivered by Spyros is to the point and specific.

Knowledge is shared well in this course.

Gives good lectures

6. Lecture Notes

- One of the points for improvement raised by the students in the first 2 years
- **Could not find any textbook** that explained the concepts as I wanted
- Lecture Notes do not cover the whole lecture material yet
  - **Every year gradually expanding them** to cover more of the lecture material, and address "Frequently Asked Questions" that come up during class
- Available on ArXiV: https://arxiv.org/pdf/1811.00943.pdf
- **Increasing visibility for DTU**:
  Receive e-mails from students and industry persons outside DTU, with comments (and thanks) about the Notes


Optimization in
Modern Power Systems

DTU Course 31765

Lecture Notes

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