ELECTRODYNAMICS

FALL 2024

The content of the course is that covered in J. D. Jacksons book (3d ed.), chapters 1-7 and 11. We will go rather quickly through statics, and several sections will be skipped, as will be clear from my lecture notes.

We will meet twice each week, on Mondays and Thursdays at 10:15, in rooms that are listed in the official schedule. Each Monday there will be a lecture presenting the topics to be covered during the coming week. The rest of the "lecturing" time will consist of discussion sessions, presentations, and exercise classes.

There are lecture notes on the course homepage. They largely replace the conventional lectures, and contain a large number of exercises and problems. Try as many as you can, and send the attempted solutions to me per email. I will then give detailed comments again per email. *Most of the actual teaching will consist of these comments* but *regular attendance on Mondays and Thursdays is strongly recommended*.

Schedule: Roughly, you are supposed to go through the topics in this order:

Week 1: Introduction and electrostatics.
Week 2: Energy and boundary value problems.
Week 3: Spherical harmonics and multipole expansions.
Week 4: Electrostatics in media
Week 5: Magnetostatics
Week 6: Relativity.
Week 7: The wave equation, the Lorenz gauge.
Week 8: Plane waves and optics.
Week 9: Wave propagation in media.

Lukas König will give four exercise classes, on spherical harmonics (September 19), magnetostatics (October 3), relativity (October 10), and the wave equation (October 14). Solutions will appear on the home page in due course. In addition he will give a "refresher lecture" on vector calculus, Stokes, etc, on September 5.

Grading: You will receive a grade depending on how many exercises/problems you solved. *Note carefully*: I count the number of final solutions. If you send

in something that I do not accept I will tell you so, and why, and *you can try again*. This offer is open until October 31. I do the counting on November 4.

The limits are Grade F: 0-9, Grade Fx: 10-14, Grade E: 15-19, Grade D: 20-24, Grade C: 25-30, Grade B: 31-∞. For grades B and C I insist that you should include at least one exercise/problem from each chapter in the notes. For the reexam, see below.

You can raise your grade one step by giving a presentation of some special topic, *and* by serving as an opponent on someone else's presentation (i.e., ask questions). The presentation is supposed to take half an hour, but this time limit is not very strict. You are free to suggest a topic of your choice. It could be a problem in Jackson's book that you find interesting. If you can't find a topic on your own, here are some suggestions:

- Cavendish's experiment. See Jackson's introduction, and search Wikipedia for further references.
- A. E. Berezin: Simple electrostatic model of the structural phase transition, Am. J. Phys. **54** (1986) 403.
- Chebyshev polynomials and electrostatics in 2D. If you have some understanding of Legendre polynomials, Wikipedia is a good reference. $\star$
- The electric field outside a sharp point, and Legendre functions of the second kind. Jackson has a good account.
- Problem 4, exactly. In the notes I asked for the first few terms of this interesting expansion. Explain how to get the exact solution in closed form. See W. R. Smythe: *Static and Dynamic Electricity*, 1939.
- The Schwarz–Christoffel transformation in 2D potential theory. (If you know analytic functions.) See Wikipedia and the first two dozen pages of Driscoll and Trefethen: *Schwarz–Christoffel mapping*, 2002.
- How to levitate a top in a magnetic field. You can look at Axel Erbing's master's thesis, 3dhouse.se/ingemar/exjobb/AxelErbing.pdf.
- G. Manfredi: Non-relativistic limits of Maxwell's equations, J. Phys. **A34** (2013) 859.
- Section 1 of D. Lynden-Bell, A magic electromagnetic field, arXiv:astro-ph/0207/064.
- Thunderstorms. See the Feynman lectures, Vol. II. $\star$
- The Hertz potential. See Białynicki-Birula and Białynicki-Birula, J. Phys. **A46** (2013) 053001.

- Gauge theory and fibre bundles. Chapters 15 and 19 in R. Penrose: *The Road to Reality*, Jonathan Cape 2004. ⋆
- The Stokes parameters. In addition to Jackson, the obvious reference is the book by Born and Wolf: *Principles of Optics*.
- How the velocity of light was determined. E. Bergstrand, Determination of the velocity of light, Handbuch der Physik Bd. XXIV.
- Did Nimtz signal faster than light? R. Y. Chiao, Tunneling times and superluminality, Prog. in Optics XXXVII, 1997, and W. Heitman and G. Nimtz, On causality proofs ..., Phys. Lett. **A196** (1994) 154.
- More to come.

If you have difficulties in accessing any of the references let me know, and we will fix it.

You can choose the topic of your presentation provided it has not been chosen by someone else (topics marked with a ⋆ are already taken), but I will assign for what presentation you will serve as opponent. I will appreciate if you do this *as soon as possible*, but I am willing to stretch the absolute deadline to October 31.

Rules for the reexam: Send in exercises in a single bunch, any time you please. I will pass or fail them as soon as I can. The limits are Grade F: 0-14, Grade Fx: 15-19, Grade E: 20-24, Grade D: 25-30, Grade C: 31-35, Grade B: 36-40, Grade A: 41-∞. For grades C, B, and A, you have to include at least one exercise from each chapter in the notes. You can include exercises you solved before if you like, but all exercises have to be numbered according to the November 1 edition of the notes.