

Bielefeld University Faculty of Physics	Symmetries in Physics WS 2025/2026	Prof. Dr. Jürgen Schnack jschnack@uni-bielefeld.de
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Problem sheet 1

1.1 IN CLASS: Refresh your knowledge

1.1.1 Refresher on Mechanics and Electrodynamics

We will make use of a few fundamental equations of Mechanics and Electrodynamics. Make sure you can explain and write down the following equations:

- Euler-Lagrange equations; advanced = the various versions,
- Hamilton's equations of motion; Poisson brackets,
- Maxwell equations; explain your units.

1.1.2 Refresher on Quantum Mechanics

The theoretical framework we will develop this semester is mostly of use in Quantum mechanics. Hence I expect you to be fluent in it. I invite you to test how much you remember about the subject, and to brush up on what you may have forgotten.

- What can you say about Hilbert spaces? States? Hermitian operators? Observables? Bases? Completeness relation? Changes of basis? Commutators? Spectral representation?
- What are the time-(in)dependent Schrödinger equations? Write them down.
- Why is quantum mechanics said to be probabilistic?
- What is a measurement?
- What is a unitary operator? Give an example.
- Does $e^{\tilde{A}}e^{\tilde{B}} = e^{\tilde{A}+\tilde{B}}$ hold if \tilde{A} and \tilde{B} are operators? Why not? When does it hold?

1.2 AT HOME: Where did you use symmetries already?

Maybe you did not notice, but you used symmetries in your studies already. Please look back and try to collect as many examples as possible from mechanics, electrodynamics, and quantum mechanics. Please also answer the following questions for each example.

- a. What was this symmetry about?
- b. Why did this symmetry hold?
- c. How did we use it and what did we gain?

Bonus: If you encountered other examples in special courses, please also collect them.