Contents

Chapter 1

Philosophy

We should discuss whether we should knock out this chapter first so that we have our bearing as we develop later chapters. Some points that are worth hitting in this section

· This work is pedagogical as opposed to something that should be used as a rigorous reference, and focused on providing a unified intuitive conceptual understanding of physical theories by providing an intuitive understanding of their mathematically rigorous component parts

· We are advanced undergraduates who recently learned this material and are therefore capable of honing in on the essential aspects of physical theory which facilitate comprehension for those just being exposed to modern physics (i.e. the key to special relativity was sincerely understanding/appreciating the unintuitive physical law of constancy of speed of light in all inertial frames, from which the Minkowski invariant interval and transformation laws/groups fall out)

· Want to show that mathematical rigor and physical intuition can and should be mutually supportive, not combative aspects of mathematical physics

We should also in each physical section always revisit the philosophical relationship between assumptions being made in the theory, things we are deducing. The philosophy behind coordinate independence, why having the metric as a posited background structure is not ideal, really make the essence of a each subtheory in physics clear and pin down these logical/theoretical and observational/experimental relationships clear.

Chapter 2

Mathematics

This section provides simultaneously provides the reader with an not-watered-down lesson in the essential techniques for mathematically formulating modern physics, while providing an intuition behind the need for these mathematical structures. Mathematics is a set of axioms, rules, and logical deductions, but we should have good physical reason for we care about a given set of abstract rules and rooted in how they map onto a physical system. Conceptual questions to address while presenting the math

- What is duality? What is covariance/contravariance?
- Why should vector fields be derivative operators?
- Why do we need forms, and why should fields (electric and magnetic fields) be forms? Maybe even show the electromagnetic two form.
- Integrating forms not differentials? What does it mean to sum over a wedge product of one forms? What is the volume form really, is there a way to think of how it acts and not just the parallelogram heuristic?
- What information does a connection/covariant derivative have? How does this information vary depending on the vector field along which we differentiate?
- What are tensor products and direct sums intuitively? (tensor product $\rightarrow$ coupling/interdependance?)
- Why are vector bundles useful (can now have a Hilbert space associated with each point on spacetime manifold-¿ quantum states can live there or whatever)?

· Perspectives on how to view representation theory/why is it useful?

Chapter 3

Classical (and Statistical?) Essentials

While we don't want to dwell on classical physics, the reader should not advance without a solid understanding of phase space, the poisson bracket, and action principles. This would be a good place to discuss Lagrangians in general what defines/makes a Lagrangian in different theories (I still don't know this, they, usually seem pulled out of someone's ass). Finally, we may want to move onto symplectic geometry and this formulation of classical physics. Action principles are generally essential, and we should take some time in this chapter to intuitively and rigorously formulate classical mechanics such that it can be naturally and elegantly bridged to quantum theory.

Chapter 4

Quantum Mechanics

Why do we need Quantum Mechanics and what *is* quantization? We should begin by answering these questions in ideally a unique way, but really just the best way. Thought that came to mind: though aspects of quantum mechanics are very unintuitive, really quantum theory forced us to question assumptions and made us develop a more careful and actually sensible formalism. Carefully discuss measurement, observation, maybe POVM. List of confusing topics to cover

- Postulates? How do we get to quantum theory
- Origin of S.E.
- Classical to quantum/ canonical quantization
- Representation theory and quantum
- Geometrical quantum?
- Clebsch-Gordan
- Wigner-Eckhart
- Entanglement
- Density Matrix
- Other that we think of
- Foray into quantum info/computation?
- Second Quantization, fock space?

Chapter 5

Relativity

What is the essence of relativity theory? Start with special, discussing questioning the metric $\rightarrow$ invariant interval from constancy of c. Then get into General Relativity. Thinks to hone in on

- Principle of equivalence and principle of general covariance
- Stress-Energy tensor physical meaning
- Origin of Einstein Equation