Preface for Instructors

For us physicists, the Standard Model is part of our everyday vocabulary. We might make casual reference to fundamental particles and forces with the expectation that our students should have picked them up at some point in their undergraduate education. However, it is rare for a curriculum to spend a full term addressing the question of what the Standard Model *is* and why, given the complexity of the particle zoo, it's supposed to be so elegant.

This work is a study in just-in-time instruction. It was developed in response to a very real need to give students context for the rest of their education. Thus, while many key concepts are derived rigorously, others are motivated by simple examples and appeals to reasonableness. This book is, in the most literal sense, intended to serve as the Standard Model in a nutshell. Students are expected to come away with not only an appreciation of the beauty of the Model but a recognition of the many remaining problems therein.

I first started writing this book because I was teaching a course to an advanced, but general, physics audience, and neither the minutiae of quantum field theory nor a focus on particle phenomenology seemed right for the audience. Those tended to be the approaches of the extant textbooks. My hope is that you might design your course similarly—as an advanced survey for cosmology or astrophysics students, or uncommitted theorists of any stripe.

This book is intended to serve a stand-alone, one-term course for advanced undergraduates and first- and second-year graduate students in physics who have already seen the following:

1. Classical electromagnetism
2. Classical mechanics, including Lagrangians
3. Nonrelativistic quantum mechanics

That's it.

I don't assume any knowledge of particle physics phenomenology, special relativity, relativistic quantum mechanics, group theory, or quantum field theory. If your curriculum differs, I anticipate a couple of other paths, including the following.

The "Classical Only" Sequence

Virtually all discussion of quantum field theory can be saved until a later course. This involves excising §5.7 as well as §7.3 and 7.4 (the initial sections, on Fermi's golden rule, remain to motivate the importance of a scattering amplitude in general). For the weak and strong interactions, instructors may skip §8.5, 9.3.3, 9.4, 10.1.4, and 11.1.4 through the end of Chapter 11.

The "Advanced Background" Sequence

While many courses will be aimed at a joint undergraduate and graduate student audience, some instructors may focus their courses on a more advanced audience. In that case, so long as students are comfortable with tensor and 4-vector notation, Chapter 1 may be skipped entirely, with the exception of $1.3.2 on natural units; §2.1 and §3.1 may also be skipped for students with a very strong background in classical mechanics. While most physics curricula do not require group theory at either the undergraduate or graduate level, for those that include a discussion of Lie groups and generators, Chapter 4 can be skipped with few consequences, though §4.4 and 4.5 on SU(2) and SU(3) are still likely to be useful.

While some graduate students may be comfortable with the Dirac equation, some care should be taken with the decision to skip Chapter 5, as the chiral representation, the symmetry properties of a Dirac field, and the quantization of the field are all likely to be new even to students who have seen relativistic quantum mechanics.

This work is not the end of the story, especially for students who want to go on to particle physics research. While I think it forms a strong foundation, departments are encouraged to develop this as the first course in a sequence which might include experimental particle physics or advanced quantum field theory—topics which students will likely take to more easily with a solid background in their motivation.