Introduction

As explained in the Preface, this book is intended for graduate students in Physics, and I assume that they had a good classical mechanics course, at an advanced undergraduate or early graduate level (from something like Goldstein's book), as well as a course in electromagnetism including the special relativistic formulation, also at an advanced undergraduate or early graduate level (for instance, the full 2 volumes of J.D. Jackson's book). Ideally, a classical field theory course as well, though familiarity with the notation of gauge theories and the language of Feynman diagrams, etc., from an advanced undergraduate course in modern or particle physics would also do.

A slight familiarity with general relativity at an undergraduate level would be useful, but it is not needed. The book is self-contained from that point of view, I do not assume anything about it, but I will not spend much time on the description of basic concepts of general relativity, preferring to spend more time on their implications. A graduate student with the above mentioned background should not have any problem in following it. In one special chapter, that has an asterisk, on the canonical quantization of gravity, I assume a basic understanding of formal (graduate or advanced undergraduate) quantum mechanics, but it should not be needed in the others.

As far as the formalism goes, I work mostly with the usual, metric formulation of general relativity, though the vielbein–spin connection formulation is also defined and used in some places. The basic formalism is described in the first 2 chapters. I then present both standard topics, like gravitational waves, the Schwarzschild solution and the classical tests of gravity, the ADM parametrization, relativistic stars and cosmology, various types of black holes, as well as more advanced standard topics, like the vielbein–spin connection formulation and its various applications, trapped surfaces, the Raychaudhuri equation, energy conditions, the Petrov and Bianchi classifications, and gravitational instantons. Then I also present more modern topics, like black hole thermodynamics and various notions of gravitational entropy, gravitoelectric and gravitomagnetic fields, effective field theory for gravity and the PPN expansion, the double copy, the fluid-gravity correspondence.

Since my goal is to equip the graduate student with the tools and knowledge for the field of general relativity, I present a large number of modern methods and applications, but I do not treat them comprehensively, but rather I focus on the essentials, so that the student can then get more detailed information by themselves.

After each chapter, I summarize a set of “Important concepts to remember,” and present 4 exercises whose solution (by the student) should clarify for them the concepts in the chapter.