Preface

This book is a short introduction to general relativity, intended primarily as a one-semester course for first-year graduate students (or for seniors) in physics, or in related subjects such as astrophysics. While we expect such students to have been exposed to special relativity in their introductory modern physics courses (most likely in their sophomore year) it is unlikely that they have used the standard 4-vector methods, and so we supply such a review in Appendix A. We strongly advise reading Appendix A first.

Most students approaching general relativity require an introduction to tensors, and these are dealt with in Chapter 1 and the first half of Chapter 2, where geodesics, absolute and covariant differentiation, and parallel transport are discussed. This enables us to discuss the spacetime of general relativity in the latter half of the chapter and takes us on to a discussion of the field equations in Chapter 3. In Chapter 4 the results learned are applied to physics in the vicinity of a massive object, where we have tried to compare general relativistic results with their Newtonian counterparts. Chapters 5 and 6, on gravitational radiation and the elements of cosmology, respectively, give further applications of the theory, but students wanting a more detailed knowledge of these topics (and indeed all topics) would have to turn to the texts referred to in the body of the book.

Over the years, a version of this course has been offered variously (by JDN) at the University of Mississippi (Ole Miss), at Bard College, and at SUNY New Paltz, as well as (by JF) at the University of Sussex. It was often found that there was not enough time for Chapters 5 and 6, unless one made judicious cuts elsewhere. A few cuts may be made in the first two chapters, but it would probably be better to omit either Chapter 5, or Chapter 6 (or both) than to omit Appendix A, since a sound knowledge of the 4-vector formalism of special relativity is an essential prerequisite.

Exercises have been provided at the end of most sections and problems at the end of chapters. The former are often quite straightforward (but possibly tedious) verifications needed for a first reading of the book, while the latter are suitable for homework-type problems.

The original version of this book was published in 1979, with translations into other languages following in the 1980s and 1990s. That version placed mathematical demands on the reader which were not entirely appropriate for a physics student, requiring him or her to acquire mathematical skills beyond what is needed for a first course in general relativity. In the second edition, the mathematical sections were completely reorganized and rewritten, so as to make the text more accessible to the physics student who had the kind of background gained from following a course in vector calculus, with applications to field theories such as Newtonian gravitation and Maxwell's theory of electromagnetism. However, for the third edition, we have restored in Appendix C much of the original material on tensors and manifolds missing from the second edition. This would be appropriate reading for mathematics majors seeking a more formal approach to tensors than physics students might desire.

The third edition also includes some minor updating. In the chapter concerning physics in the vicinity of a massive object (Chapter 4) we have added a short section on the Kerr solution and its relevance to the *Gravity Probe B* experiment launched in 2004; and the chapter on cosmology (Chapter 6) has been supplemented by two sections concerning redshift and galaxy recession with speeds greater than that of light.

With gratitude, mention must be made of John Ray, Richard Halpern, Peter Skiff, Jeffrey Dunham, and Tarun Biswas, all of whom have been of assistance in one way or another. Marc Bensadoun kindly supplied the figure showing the measurements of cosmic background microwave radiation in Chapter 6 and gave us permission to reproduce it here. The first edition of the book was completed with the help and exemplary typing skills of Jill Foster, whose transcription of the original text to computer files served as a foundation for its revision and conversion to LaTeX format. We are also grateful to J. Snider, M.E. Horn, and N.B. Speyer for providing us with lists of errors from the first and second editions.

We have also included at the end of the book outline solutions (which are not model answers, and for which the student must supply all the details). Further, a beautifully written and detailed solution set for the exercises and problems is available from Professor J.S. Dunham, Department of Physics, Middlebury College, Middlebury, Vermont 05753.

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