

Preface

This is an introductory book on the general theory of relativity based partly on lectures given to students of M.Sc. Physics at my university.

The book is divided into three parts. The first part is a preliminary course on general relativity with minimum preparation. The second part builds the mathematical background and the third part deals with topics where mathematics developed in the second part is needed.

The first chapter gives a general background and introduction. This is followed by an introduction to curvature through Gauss' Theorema Egregium. This theorem expresses the curvature of a two-dimensional surface in terms of intrinsic quantities related to the infinitesimal distance function on the surface. The student is introduced to the metric tensor, Christoffel symbols and Riemann curvature tensor by elementary methods in the familiar and visualizable case of two dimensions. This early introduction to geometric quantities equips a student to learn simpler topics in general relativity like the Newtonian limit, red shift, the Schwarzschild solution, precession of the perihelion and bending of light in a gravitational field.

Part II (chapters 5 to 10) is an introduction to Riemannian geometry as required by general relativity. This is done from the beginning, starting with vectors and tensors. I believe that students of physics grasp physical concepts better if they are not shaky about the mathematics involved.

There is perhaps more mathematics in Part II than strictly required for Part III of this introductory book. My aim has been that, after reading the book, a student should not feel discouraged when she opens advanced texts on general relativity for further reading. The advanced books introduce mathematical concepts far too briefly to be really useful to a student. And the student feels lost in the pure mathematical textbooks on differential geometry. In that sense, this book offers to fill a gap.

The final part is devoted to topics that include the action principle, weak gravitational fields, gravitational waves, Schwarzschild and Kerr solutions and the Friedman equation in cosmology. A few special topics are touched upon in the final chapter.

Many exercises are provided with hints and very often complete solutions in the last section of chapters. These exercises contain material which cannot be

ignored and has been put in this format purposely to help students learn on their own.

Note

I have generally used the female gender for the imagined student reader of the book, but occasionally, the male pronouns ‘he’ or ‘his’ are also slipped in for political correctness.

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