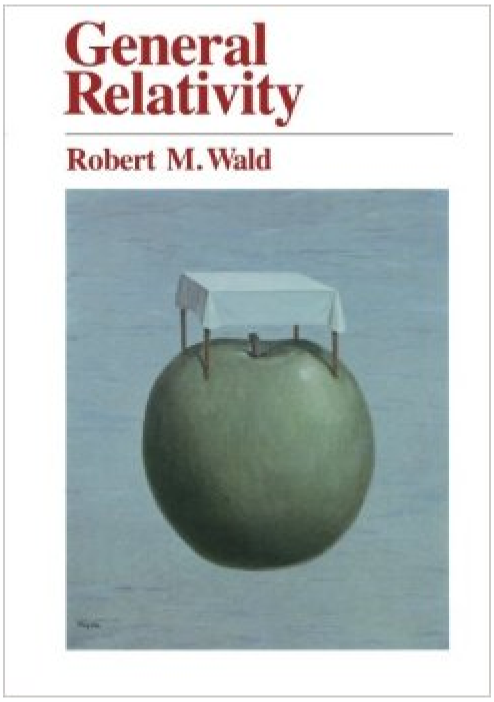
General Relativity



Synopsis

"Wald’s book is clearly the first textbook on general relativity with a totally modern point of view; and it succeeds very well where others are only partially successful. The book includes full discussions of many problems of current interest which are not treated in any extant book, and all these matters are considered with perception and understanding."â ”S. Chandrasekhar"A tour de force: lucid, straightforward, mathematically rigorous, exacting in the analysis of the theory in its physical aspect."â ”L. P. Hughston, Times Higher Education Supplement"Truly excellent. . . . A sophisticated text of manageable size that will probably be read by every student of relativity, astrophysics, and field theory for years to come."â ”James W. York, Physics Today

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Customer Reviews

I found Wald’s book to be better as an introduction than MTW. However, you’ll probably want to get both books since you’ll need them if you’re going to really understand GR. Here are some points:1) Wald is more concise than MTW. MTW tries to make differential geometry "intuitive" through some, in my opinion, poorly choosen concepts. So I found Wald to be much more understandable.2) The book is much shorter than MTW so it is a little less daunting of a task. Wald still covers all the basics so you are not cheated out of any topics.3) Do not expect to learn the differential geometry you need from Wald’s Chapters 2 and 3 and appendices. A nice cheap book is Lovelock and Rund’s "Tensors, Differential Forms and Variational Principles" (Dover). This book is surprisingly good and will cover the topics in a very understandable way in as few pages as possible. This allows you to get on with GR as quickly as possible. Read a chapter in Lovelock and Rund and then read the corresponding section in Wald. This allows you to understand both the concept and Wald's notation. I found the two books worked perfectly together.Enjoy!

There have been many books written on general relativity from both a physical and mathematical viewpoint, but this one stands out as one that is a hybrid between mathematical rigor and physical insight. It is certainly written for the physics student, but mathematicians interested in general relativity can certainly benefit from its perusal. I only read the first nine chapters of the book, so my review will be limited to these.The first chapter is a short introduction to special relativity put in by the author for motivation. And, instead of introducing the mathematical formalism "as needed" in the book, the author chooses to outline it in detail in chapters two and three. The approach taken is a "modern" coordinate-free one, at least from the standpoint of differential geometry, but he delegates to an appendix the relevant background in topology. Since he is targeting the physicist reader, he does not hesitate to use diagrams to explain the concepts. The author introduces the idea of a dual vector using the example of a magnetic field. Tensors are then defined with great clarity from the standpoint of mathematical rigor. The physicist reader may have trouble digesting this if seeing tensors defined this way for the first time, instead of via their transformations properties, as is typically done. The abstract index notation is introduced to deal with the plethora of indices involved in manipulating tensors. In the treatment of geodesics, the author shows that it is sufficient to consider curves that are affinely parametrized, and the geodesic equation is derived in a coordinate basis. Riemannian and Gaussian normal coordinates are discussed as consequences of the unique solution of the geodesic equation. Curvature is also characterized in terms of the geodesic equation and two methods for calculating it are discussed: the coordinate component and tetrad methods, with the Newman-Penrose method briefly discussed. The existence of symbolic programming languages such as Mathematica and Maple make tensor manipulation much less laborius than the author contends in the book.In the next chapter, the principle of general covariance is introduced as one that prohibits the existence of perferred vector fields in the laws of physics. The metric is the only quantity permitted to be related to space in the laws of physics. Thus quantities such as the Christoffel symbols, cannot appear in these laws. The author discusses in detail how general relativity views gravitation in terms of curved spacetime geometry and how Mach's principle is incorporated, the later forcing the spacetime metric to be a dynamical variable. The author discusses the difficulty in solving the Einstein equation, namely that a simultaneous solution for the spacetime metric and matter distribution is required (since the stress-energy tensor, the "source", requires knowledge of the spacetime metric for its interpretation). The linearized theory is discussed in detail along with the Newtonian limit. Gravitational waves are shown to follow from the linearized Einstein equation. The effect of energy loss on the orbital period of the Taylor-McCulloch binary star system is discussed as an experimental verification of general relativity.Applications to cosmology are given in chapter 5, which is restricted to the case of homogeneous, isotropic cosmologies. The reader gets introduced to the famous Hubble constant, along with Robertson-Walker and Friedman solutions. A fairly lengthy overview of the evolution of the universe is given.The next chapter is devoted entirely to the Schwarzschild solution, which is used to discuss the four experimental verifications of general relativity, namely the gravitational redshift, the precession of Mercury's orbit, bending of light by the Sun, and the time delay of radar signals. The singularities in the Schwarzschild solution are treated via the Kruskal extension.Methods for obtaining physically realistic solutions are discussed in chapter 7, most of these being obtained by exploiting stationarity and symmetry properties. Perturbation theory is discussed very briefly with no explicit examples given.Topics of a more mathematical nature appear in chapter 8, wherein the causal structure of spacetime is discussed. The discussion is qualitative and not based on Einsteins equation, and so is applicable to general spacetimes. One wonders when reading it if the obtained framework can be based on an analytical (or possibly numerical) treatment of the Einstein equation, instead of pure differential geometry. It is shown that null geodesics are The discussion here sets the tone for the next chapter on singularities, wherein the author derives criteria for determining when a timelike geodesic is not a local maximum in proper time between two points, and for when a null geodesic fails to remain on the boundary of the future of a point or two-dimensional surface. By using the local positivity of the stress-energy tensor (this is the only place the Einstein equation gets used) to get an inequality on the Ricci tensor, the author shows that timelike geodesics cannot be maximal length curves and null geodesics cannot remain on past or future boundaries. However, using compactness properties of the space of causal curves allows one to prove the existence of timelike and nullike curves of maximal length in globally hyperbolic spacetimes. The singularity theorems are shown to follow from this contraction, giving the result that spacetime is timelike or nulllike incomplete. A very detailed discussion of the definition of a singularity in physics is given. In all of the author's discussion, it is very interesting to note that the Einstein equation is only used once in obtaining the bound on the Ricci tensor. One naturally wonders if this framework is more general than what is available via general relativity, namely a question to ask is whether the Einstein notion of gravity can be derived from a consideration of singularities. Enforcing the presence (or absence) of singularities may allow the derivation of gravitational theories that are not the same as Einsteins, and yet have the same experimental success.

This book was a little scary to read the first time I opened it. Abstract Indices all over. OMG, What does this upside down triangle mean? Where did this strange L come from? These are the sort of questions you will be asking yourself if you try to read this book without adequate preparation in Differential Geomtery. Sure Wald has 2 chapter devoted to this, but thats like asking you to learn all the vocabulary that you have in english from 5 little summary sheets. However once you do know soemthing about Riemannian Geomtery(an excellent elementary source is the book by Bishop and Goldberg "Tensor Analysis by Manifolds"), this book is a joy to read. Every explanation is crystal clear, and makes for a very enlightening experience overall. There’s no need to read between the lines that some books expect you to, and Wald dosent insult his reader’s intelligence either. This books is written for serious students of relativity, be it applied mathematicians or physicists. For the people willing to patiently read the book, and learn the details he presents, this book is probably the best preparation to general relativity. One complaint however is the noticeable shortage in exercises. And the ones supplied arent particularly difficult either. But all in all, an amazing read.

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