

Solutions to *General Relativity* by Wald

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Chapter 2 Solutions

1. a) Show that the overlap functions $f_i^\pm \circ (f_j^\pm)^{-1}$ are C^∞ , thus completing the demonstration given in section 2.1 that S^2 is a manifold.

b) Show by explicit construction that two coordinate systems (as opposed to the six used in the text) suffice to cover S^2 . (It is impossible to cover S^2 with a single chart, as follows from the fact that S^2 is compact, but every open subset of $\mathbb{R}^2$ is noncompact.)

a) The maps are defined as acting on the standard embedding of the sphere into $\mathbb{R}^3$. $f_i^\pm$ is a projection of upper (lower) hemisphere into the plane, for example

$$f_2^\pm(x^1, x^2, x^3) = (x^1, x^2),$$

and the others are similar. The inverse map stretches the plane up or down into the corresponding hemisphere,

$$(f_2^\pm)^{-1}(y^1, y^2) = (y^1, \pm\sqrt{1 - ((y^1)^2 + (y^2)^2)}, y^2),$$

and so on. The overlap map then projects out two of these coordinates, so up to exchanging coordinates it is either of the two maps

$$\begin{aligned} (y^1, y^2) &\mapsto (y^1, y^2) \\ (y^1, y^2) &\mapsto (y^1, \pm\sqrt{1 - ((y^1)^2 + (y^2)^2)}), \end{aligned}$$

both of which are C^∞ in their domain of definition, $(y^1)^2 + (y^2)^2 < 1$.

b) Construct a chart by drawing a line from the north pole N through any given point $p \neq N$ on the sphere. The point where this line hits the plane $x^3 = 0$ is the image of p under the chart. This map is defined for all points except N and is called stereographic projection from N . A similar chart defined at S (or any other chart about S) then together with the first form an atlas for S^2 . An explicit form of the map can be found geometrically. The line through p and N (thought of as vector in $\mathbb{R}^3$) is (with $N = (0, 0, 1)$)

$$p + t(p - N) = (t(1 + p^1), t(1 + p^2), t(1 + p^3) - t).$$

Solving for when $x^3 = 0$ we get

$$t = \frac{p^3}{1 - p^3},$$

which then gives

$$x^i = \frac{p^i}{1 - p^3}.$$

The inverse maps are found similarly by starting with a point (y^1, y^2) in the plane, constructing the line $N + t(N - y)$ through N and y and finding where this hits the sphere:

$$1 = |x(t)|^2 = (y^1)^2 t^2 + (y^2)^2 t^2 + (t + 1)^2,$$

which has solution

$$t = \frac{-2}{1 + |y|^2},$$

and gives the mapping

$$(y^1, y^2) \mapsto \frac{1}{1 + |y|^2} (2y^1, 2y^2, |y|^2 - 1).$$

General Relativity Wald Solutions Manual

Daniela Niemeyer



General Relativity Wald Solutions Manual:

300 Problems in Special and General Relativity Mattias Blennow, Tommy Ohlsson, 2021-12-09 Einstein's theories of special relativity and general relativity form a core part of today's undergraduate or Masters level physics curriculum. This is a supplementary problem book or student's manual consisting of 150 problems in each of special and general relativity. The problems, which have been developed, tested, and refined by the authors over the past two decades, are a mixture of short form and multi-part extended problems with hints provided where appropriate. Complete solutions are elaborated for every problem in a different section of the book; some solutions include brief discussions on their physical or historical significance. Designed as a companion text to complement a main relativity textbook, it does not assume access to any specific textbook. This is a helpful resource for advanced students for self-study, a source of problems for university teaching assistants or as inspiration for instructors and examiners constructing problems for their lectures, homework, or exams. **General**

Relativity Robert M. Wald, 2010-05-15 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. S Chandrasekhar: A tour de force, lucid, straightforward, mathematically rigorous, exacting in the analysis of the theory in its physical aspect. 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. James W York: Physics Today. *Core List of Books and Journals in Science and Technology* Russell H. Powell, James R. Powell, 1987-10

Whitaker's Cumulative Book List, 1984 Paperbound Books in Print, 1991 Exploring Osaka David M. Dunfield, 1993: A comprehensive English language guide to the city of Osaka for business travellers and tourists alike. Second only to Tokyo as a banking and trade centre of Japan, Osaka is a centre of tradition and culture as well the home of bunraku puppet theatre for example and is minutes by rail from Japan's ancient capitals of Kyoto and Nara. A variety of suggested sightseeing itineraries are included as well as recommended museums, restaurants, and hotels, a list of festival dates, and sources of additional information. *Scientific and Technical Books and Serials in Print*, 1989 **Global Spacetime**

Structure JB Manchak, 2020-12-03: This exploration of the global structure of spacetime within the context of general relativity examines the causal and singular structures of spacetime, revealing some of the curious possibilities that are compatible with the theory, such as time travel and holes of various types. Investigations into the epistemic and modal structures of spacetime highlight the difficulties in ruling out such possibilities, unlikely as they may seem at first. The upshot seems to be that what counts as a physically reasonable spacetime structure in modern physics is far from clear. A Student's Manual for A First Course in General Relativity Robert B. Scott, 2016-01-21: This comprehensive student manual has been designed to accompany the leading textbook by Bernard Schutz, *A First Course in General Relativity*, and uses detailed

solutions cross referenced to several introductory and more advanced textbooks to enable self learners undergraduates and postgraduates to master general relativity through problem solving The perfect accompaniment to Schutz s textbook this manual guides the reader step by step through over 200 exercises with clear easy to follow derivations It provides detailed solutions to almost half of Schutz s exercises and includes 125 brand new supplementary problems that address the subtle points of each chapter It includes a comprehensive index and collects useful mathematical results such as transformation matrices and Christoffel symbols for commonly studied spacetimes in an appendix Supported by an online table categorising exercises a Maple worksheet and an instructors manual this text provides an invaluable resource for all students and instructors using Schutz s textbook

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