

# Solutions to *General Relativity* by Wald

Daniel J. Cross

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## Chapter 2 Solutions

1. a) Show that the overlap functions  $f_i^\pm \circ (f_j^\pm)^{-1}$  are  $C^\infty$ , 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  $C^\infty$  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

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

# Solutions Manual Wald General Relativity

**SJ Ball**



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A Student's Manual for A First Course in General Relativity Robert B. Scott, 2016 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

*300 Problems in Special and General Relativity* Mattias Blennow, Tommy Ohlsson, 2021-12-09 A textbook neutral problems and solutions book that complements any relativity textbook at advanced undergraduate or masters level

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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

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James W York *Physics Today*

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**Scientific and Technical Books and Serials in Print**, 1989

**Subject Guide to Books in Print**, 2001

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Global Spacetime Structure JB Manchak, 2020-12-03

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