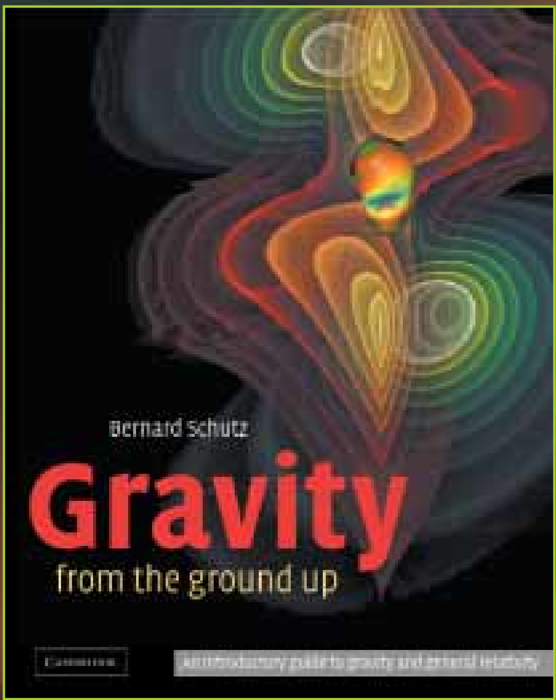
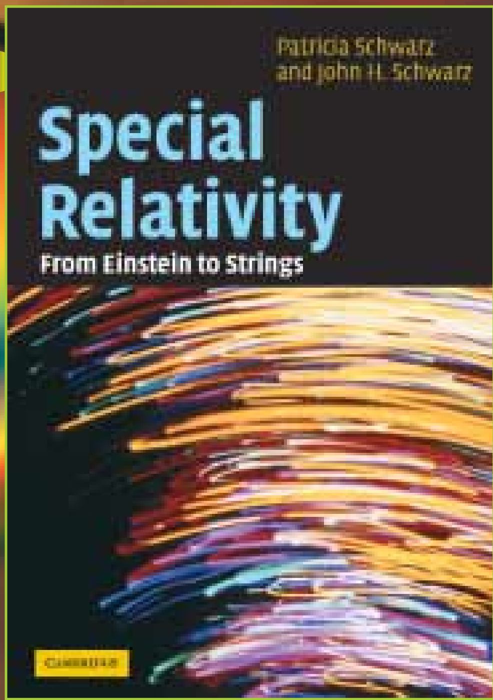
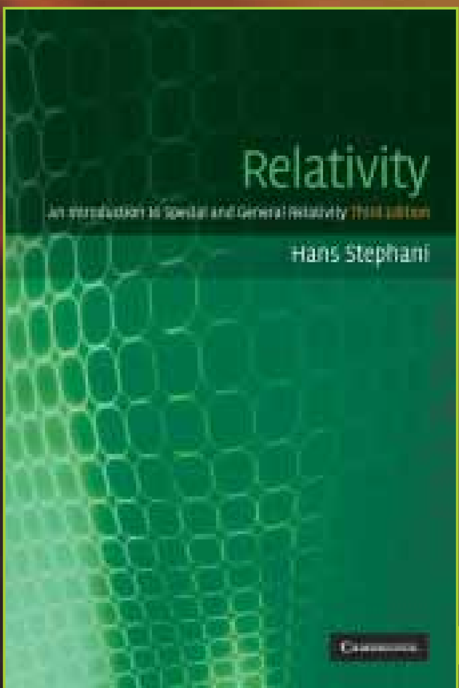
CAMBRIDGE

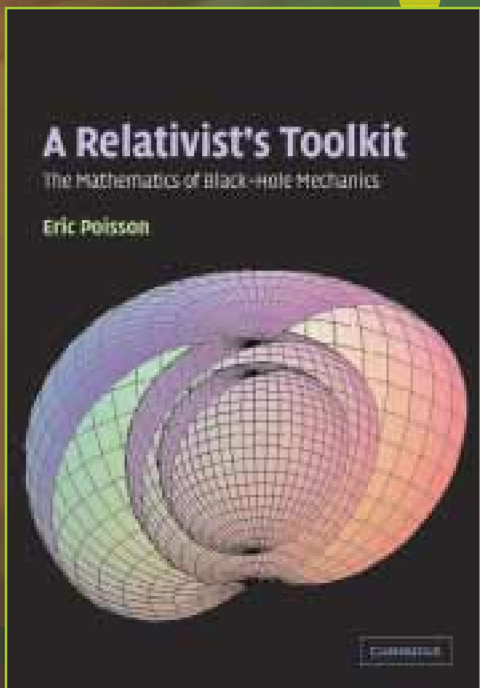
Relativity textbooks

From early undergraduate to graduate courses, Cambridge has a relativity textbook at the right level.

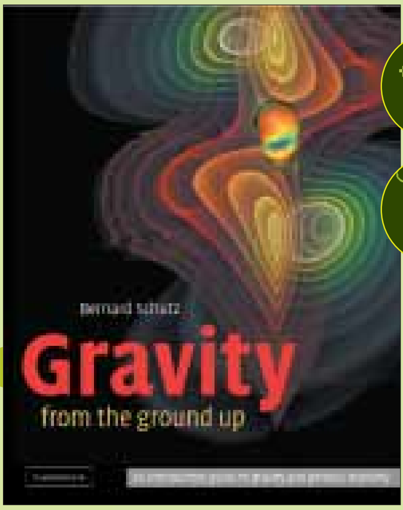








http://www.cambridge.org/physics/relativity



Gravity from the Ground Up

An Introductory Guide to Gravity and General Relativity

Bernard F. Schutz
Max-Planck-Institut für Gravitationsphysik, Germany

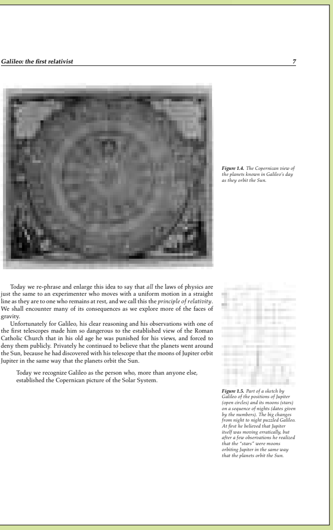
Advance praise:

'… A marvellous work! What strikes me is its immense range and its solid authority. For me this will be a great resource of encyclopedic knowledge, powerful models, and balanced judgement about our Universe.'

PROFESSOR EDWIN F. TAYLOR
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Key features:

- **Highly accessible introduction to astronomy and general relativity**
- **Imaginative use of high-school mathematics and computer programs to explain deep physics**
- **Tied to a website providing programs, solutions to exercises and other useful resources: www.gravityfromthegroundup.org**


Galileo: the first relativist 7

Today we re-phrase and enlarge this idea to say that *all* the laws of physics are just the same to an experimenter who moves with a uniform motion in a straight line as they are to one who remains at rest, and we call this the *principle of relativity*. We shall encounter many of its consequences as we explore more of the faces of gravity.

Unfortunately for Galileo, his clear reasoning and his observations with one of the first telescopes made him so dangerous to the established view of the Roman Catholic Church that in his old age he was punished for his views, and forced to deny them publicly. Privately he continued to believe that the planets went around the Sun, because he had discovered with his telescope that the moons of Jupiter orbit Jupiter in the same way that the planets orbit the Sun.

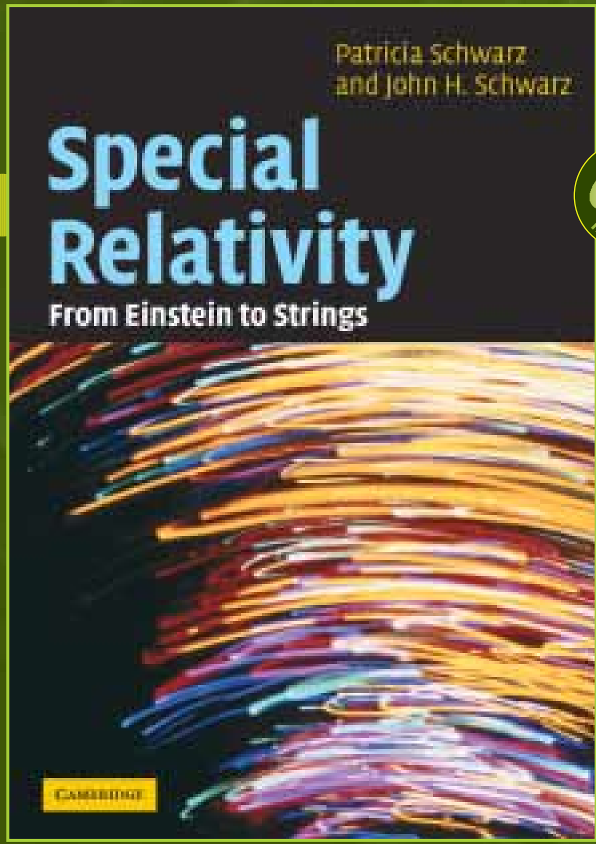
Today we recognize Galileo as the person who, more than anyone else, established the Copernican picture of the Solar System.

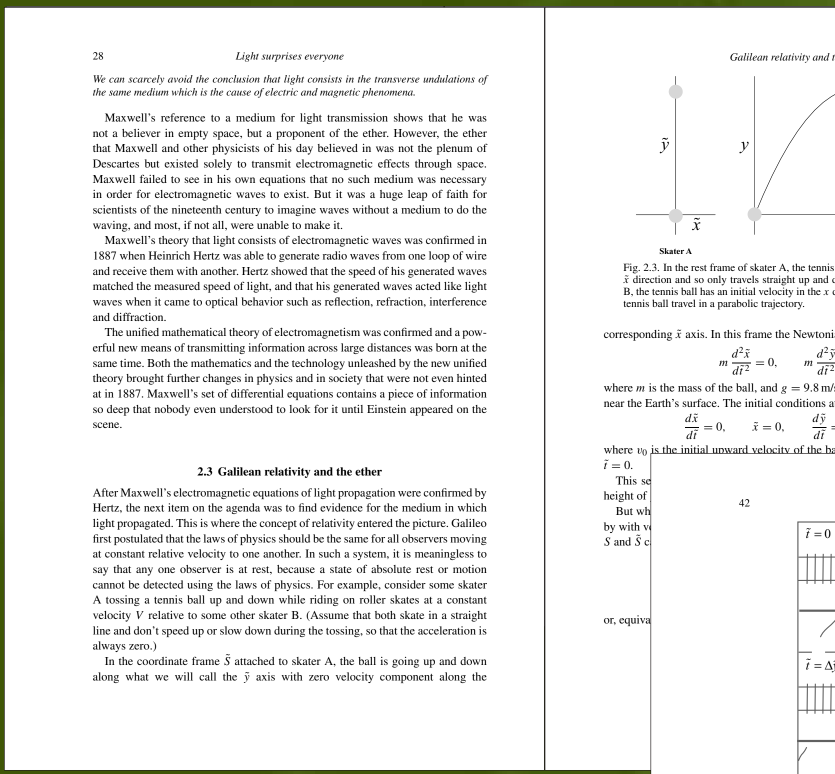
Figure 1.4. *The Copernican view of the planets known in Galileo's day as they orbit the Sun.*

Figure 1.5. *Part of a sketch by Galileo of the positions of Jupiter (open circles) and its moons (stars) on a sequence of nights (dates given by the numbers). The big changes from night to night puzzled Galileo. At first he believed that Jupiter itself was moving erratically, but after a few observations he realized that the "stars" were moons orbiting Jupiter in the same way that the planets orbit the Sun.*

Contents

2003	253 x 203 mm	488pp
75 line diagrams	80 half-tones10 tables	100 exercises
0 521 45506 5	Hardback	£ 30.00




28 *Light surprises everyone*

We can scarcely avoid the conclusion that light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena.

Maxwell's reference to a medium for light transmission shows that he was not a believer in empty space, but a proponent of the ether. However, the ether that Maxwell and other physicists of his day believed in was not the plenum of Descartes but existed solely to transmit electromagnetic effects through space. Maxwell failed to see in his own equations that no such medium was necessary in order for electromagnetic waves to exist. But it was a huge leap of faith for scientists of the nineteenth century to imagine waves without a medium to do the waving, and most, if not all, were unable to make it.

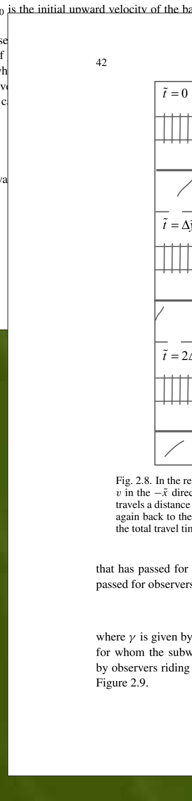
Maxwell's theory that light consists of electromagnetic waves was confirmed in 1887 when Heinrich Hertz was able to generate radio waves from one loop of wire and receive them with another. Hertz showed that the speed of his generated waves matched the measured speed of light, and that his generated waves acted like light waves when it came to optical behavior such as reflection, refraction, interference and diffraction.

The unified mathematical theory of electromagnetism was confirmed and a powerful new means of transmitting information across large distances was born at the same time. Both the mathematics and the technology unleashed by the new unified theory brought further changes in physics and in society that were not even hinted at in 1887. Maxwell's set of differential equations contains a piece of information so deep that nobody even understood to look for it until Einstein appeared on the scene.

2.3 Galilean relativity and the ether

After Maxwell's electromagnetic equations of light propagation were confirmed by Hertz, the next item on the agenda was to find evidence for the medium in which light propagated. This is where the concept of relativity entered the picture. Galileo first postulated that the laws of physics should be the same for all observers moving at constant relative velocity to one another. In such a system, it is meaningless to say that any one observer is at rest, because a state of absolute rest or motion cannot be detected using the laws of physics. For example, consider some skater A tossing a tennis ball up and down while riding on roller skates at a constant velocity V relative to some other skater B. (Assume that both skate in a straight line and don't speed up or slow down during the tossing, so that the acceleration is always zero.)

In the coordinate frame $\tilde{S}$ attached to skater A, the ball is going up and down along what we will call the $\tilde{y}$ axis with zero velocity component along the



Contents

2004	247 x 174 mm	415pp
39 line diagrams	2 tables	144 exercises
0 521 81260 7	Hardback	£ 30.00

Special Relativity

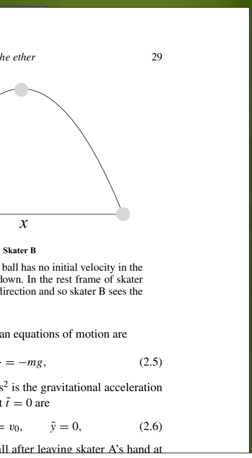
From Einstein to Strings

Patricia Schwarz
and John H. Schwarz
California Institute of Technology

This book provides a thorough introduction to Einstein's special theory of relativity, suitable for anyone with a minimum of one year's university physics with calculus. It is divided into fundamental and advanced topics. The first section starts by recalling the Pythagorean rule and its relation to the geometry of space, then covers every aspect of special relativity, including the history. The second section covers the impact of relativity in quantum theory, with an introduction to relativistic quantum mechanics and quantum field theory. It also goes over the group theory of the Lorentz group, a simple introduction to supersymmetry, and ends with cutting-edge topics such as general relativity, the standard model of elementary particles and its extensions, superstring theory, and a survey of important unsolved problems. Each chapter comes with a set of exercises. The book is accompanied by a CD-ROM illustrating, through interactive animation, classic problems in relativity involving motion.

Key features:

- **Treats advanced topics in relativity such as particle physics, supersymmetry, string theory and causality at a level suitable for undergraduates**
- **A fully up-to-date treatment of special relativity in any number of spacetime dimensions**
- **A CD accompanies the book that illustrates problems involving relative motion using interactive animations**


he ether 29

x

Skater B

ball has no initial velocity in the
down. In the rest frame of skater
direction and so skater B sees the

an equations of motion are

$= -mg,$ (2.5)

s^2 is the gravitational acceleration
t $\tilde{t} = 0$ are

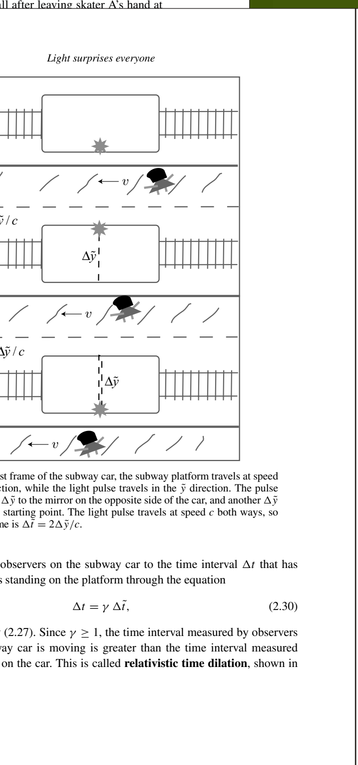
$= v_0, \quad \tilde{y} = 0,$ (2.6)

ll after leaving skater A's hand at

Advance Praise

"Patricia and John Schwarz have created an elegant book that uses special relativity to organize a sophisticated discussion of Maxwell theory, differential geometry, symmetry, and field dynamics. This book will reveal to the student the powerful tools that enhance our comprehension of physical theories."

PROFESSOR BARTON ZWIEBACH
MASSACHUSETTS INSTITUTE OF TECHNOLOGY


Light surprises everyone

st frame of the subway car, the subway platform travels at speed
ction, while the light pulse travels in the $\tilde{y}$ direction. The pulse
$\Delta\tilde{y}$ to the mirror on the opposite side of the car, and another $\Delta\tilde{y}$
starting point. The light pulse travels at speed c both ways, so
ne is $\Delta\tilde{t} = 2\Delta\tilde{y}/c$.

observers on the subway car to the time interval Δt that has
s standing on the platform through the equation

$$\Delta t = \gamma\,\Delta\tilde{t}, \quad (2.30)$$

(2.27). Since $\gamma \geq 1$, the time interval measured by observers
ay car is moving is greater than the time interval measured
on the car. This is called **relativistic time dilation**, shown in

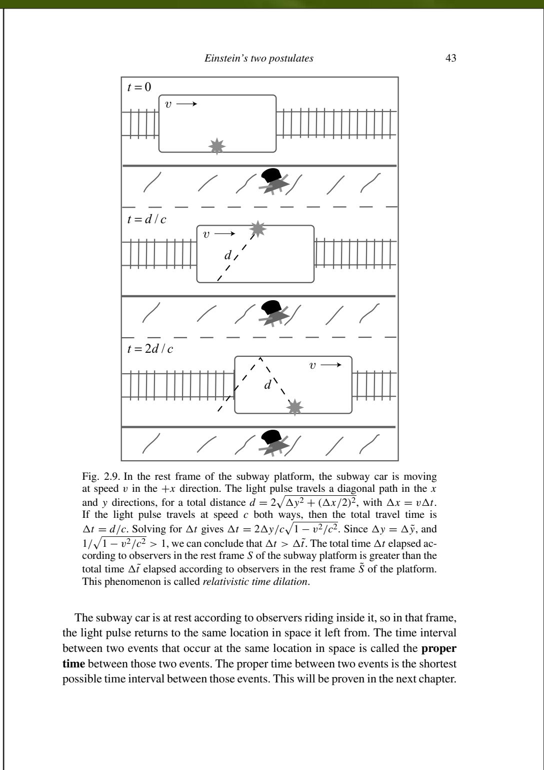
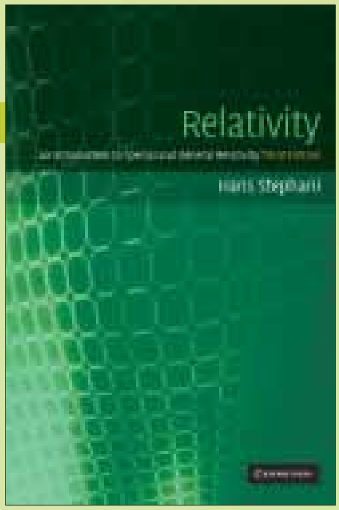

Einstein's two postulates 43

Fig. 2.9. In the rest frame of the subway platform, the subway car is moving at speed v in the $+x$ direction. The light pulse travels a diagonal path in the x and y directions, for a total distance $d = 2\sqrt{\Delta y^2 + (\Delta x/2)^2}$, with $\Delta x = v\Delta t$. If the light pulse travels at speed c both ways, then the total travel time is $\Delta t = d/c$. Solving for Δt gives $\Delta t = 2\Delta y/c\sqrt{1 - v^2/c^2}$. Since $\Delta y = \Delta\tilde{y}$, and $1/\sqrt{1 - v^2/c^2} > 1$, we can conclude that $\Delta t > \Delta\tilde{t}$. The total time Δt elapsed according to observers in the rest frame S of the subway platform is greater than the total time $\Delta\tilde{t}$ elapsed according to observers in the rest frame $\tilde{S}$ of the platform. This phenomenon is called *relativistic time dilation*.

The subway car is at rest according to observers riding inside it, so in that frame, the light pulse returns to the same location in space it left from. The time interval between two events that occur at the same location in space is called the **proper time** between those two events. The proper time between two events is the shortest possible time interval between those events. This will be proven in the next chapter.



Relativity

An Introduction to Special and General Relativity

Third edition

Hans Stephani
Friedrich-Schiller-Universität Jena, Germany

Thoroughly revised and updated, this textbook provides a pedagogical introduction to relativity. It covers the most important features of both special and general relativity, as well as touching on more difficult topics. The necessary mathematical tools (tensor calculus, Riemannian geometry) are provided, most of the derivations are given in full, and exercises are included where appropriate. The bibliography gives the original papers and directs the reader to useful monographs and review papers.

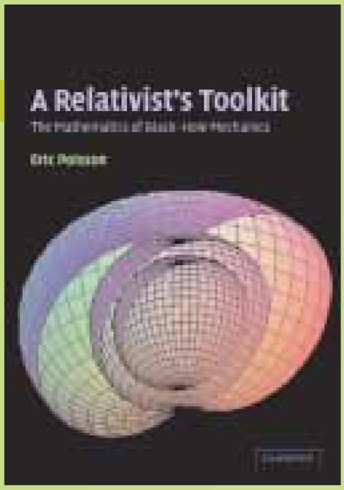
Key features:

- **Thoroughly revised and updated new edition, now including a large section on special relativity**
- **Clear, self-contained and concise textbook**
- **Suitable for undergraduate and beginning graduate courses**

Contents

2004 228 x 152 mm 416pp 3 tables 102 exercises 81 figures
0 521 01069 1 Paperback £ 30.00

Please order from your bookseller



A Relativist's Toolkit

The Mathematics of Black-Hole Mechanics

Eric Poisson
University of Guelph, Ontario

This textbook fills a gap in the existing literature on general relativity by providing the advanced student with practical tools for the computation of many physically interesting quantities. The context is provided by the mathematical theory of black holes, one of the most elegant, successful, and relevant applications of general relativity. Among the topics discussed are congruences of timelike and null geodesics, the embedding of spacelike, timelike, and null hypersurfaces in spacetime, and the Lagrangian and Hamiltonian formulations of general relativity. Although the book is self-contained, it is not meant to serve as an introduction to general relativity. Instead, it is meant to help the reader acquire advanced skills and become a competent researcher in relativity and gravitational physics. The primary readership consists of graduate students in gravitational physics. It will also be a useful reference for more seasoned researchers working in this field.

Key features:

- **Short, concise and to-the-point**
- **Focuses on practical methods of computation in general relativity**
- **Provides advanced skills for those beginning research in this field**

Contents

2004	247 x 174 mm	240pp
39 line diagrams	3 tables	46 exercises
0 521 83091 5	Hardback	£ 35.00

CAMBRIDGE UNIVERSITY PRESS
www.cambridge.org

ISBN 0-521-91943-6

9 780521 919432 >

Printed in the United Kingdom at the University Press, Cambridge

March 2004