

Cambridge University Press

978-0-521-76394-3 - An Illustrated Guide to Relativity

Tatsu Takeuchi

Table of Contents

[More information](#)

## Contents

<b>Preface to English edition</b>	<i>page</i> viii
<b>Preface to Japanese edition</b>	ix
<b>Part I Kinematics: Relativity without any equations</b>	1
<b>1 Welcome to the world of relativity</b>	2
<b>2 Basics</b>	4
2.1 Questions about motion	4
2.2 Frames of reference	5
2.3 Relativity of motion	12
2.4 The Law of Inertia	14
2.5 Inertial and non-inertial frames	18
2.6 What's so "special" about Special Relativity?	26
<b>3 Galilean relativity</b>	30
3.1 Basic questions	30
3.2 Spacetime diagrams	34
3.3 The Galilei transformation	40
3.4 Addition of velocities	54
3.5 Acceleration and Newton's Second Law	56
<b>4 Einsteinian relativity</b>	59
4.1 The mystery of the speed of light	59
4.2 Modification to the spacetime diagram	64
4.3 The problem	66
4.4 The solution	72
4.5 Einstein's argument	80
4.6 The solution, continued	85
4.7 Conservation of spacetime volume	88
4.8 The Lorentz transformation	94
4.9 The low velocity limit of the Lorentz transformation	108

Cambridge University Press

978-0-521-76394-3 - An Illustrated Guide to Relativity

Tatsu Takeuchi

Table of Contents

[More information](#)

4.10	Addition of velocities	110
4.11	Dependence of inertia on speed	116
<b>5</b>	<b>Causality</b>	120
5.1	Before and after	120
5.2	Paradox?	122
5.3	Instantaneous communication?	124
5.4	Impossibility of faster than light travel	126
5.5	The light-cone	128
<b>6</b>	<b>Consequences</b>	130
6.1	Synchronization of clocks	130
6.2	Time dilation	132
6.3	What time dilation DOES NOT mean	138
6.4	Lorentz contraction	140
6.5	What Lorentz contraction DOES NOT mean	146
6.6	Twin paradox	148
6.7	Doppler effect	154
6.7.1	Red shift	156
6.7.2	Blue shift	158
6.7.3	Red shift and the expansion of the universe	160
<b>7</b>	<b>Summary of Part I</b>	162
 <b>Part II Problems</b>		165
<b>8</b>	<b>Qualitative problems</b>	166
8.1	Reading the spacetime diagram	166
8.1.1	Street lamps	166
8.1.2	Supernovae	168
8.2	Questions on before and after	170
8.2.1	The hare and the tortoise 1	170
8.2.2	The hare and the tortoise 2	172
8.2.3	The hare and the tortoise 3	174
8.2.4	The starship and the supernova	176
8.3	Relativistic sports	178
8.3.1	Tagging up in baseball 1	178
8.3.2	Tagging up in baseball 2	180
8.3.3	The offside rule in soccer	182
8.4	Lorentz contraction	184
8.4.1	Train and tunnel	184
8.4.2	The starship and the enemy space cruiser 1	186

	<i>Contents</i>	vii
8.4.3 The starship and the enemy space cruiser	2	188
8.4.4 The duel of the space cruisers	190	
8.4.5 Trains in a tunnel	192	
<i>Solutions to Chapter 8 problems</i>	194	
<b>9 Quantitative problems</b>	200	
9.1 Addition of velocities	200	
<b>Part III Dynamics: Relativity with a few equations</b>	207	
<b>10 The world's most famous equation</b>	209	
<b>11 The problem</b>	210	
<b>12 Newtonian dynamics</b>	212	
12.1 The mass-momentum vector	212	
12.2 The impulse vector	218	
12.3 Inertial mass	220	
12.4 Newton's Second Law	222	
12.5 Newton's Third Law and the conservation of mass-momentum	224	
<b>13 Relativistic dynamics</b>	230	
13.1 The energy-momentum vector	230	
13.2 The energy-momentum vector of a photon	236	
13.3 The work-impulse vector	240	
13.4 Conservation of energy-momentum	244	
13.5 $E = mc^2$	246	
13.6 Common misconception about $E = mc^2$	248	
<b>14 Summary of Part III</b>	251	
<i>Afterword</i>	252	
<i>References</i>	254	
<i>Index</i>	255	