

Contents

Acknowledgments	xi
Introduction	1
1 Classical and quantum mechanics	3
1.1 Mathematical details	3
1.1.1 Classical theories	3
1.1.2 Quantum theories	5
1.1.3 Hilbert Space representation	6
1.1.4 Quantum states	11
1.1.5 Summing up	15
1.2 Conceptual problems and some quantum paradoxes	15
1.2.1 Early disturbance interpretations	15
1.2.2 Schrödinger's cat	16
1.2.3 The EPR experiment	19
1.2.4 Complementarity	22
1.2.5 The two-slit experiment	24
1.2.6 Quantum logic	25
1.3 Why use logic?	27
2 Modern logic	29
2.1 Introduction to logic	29
2.1.1 Propositions	29
2.1.2 Valuations	31
2.1.3 The structure of a logic	34
2.1.4 Axiomatics	36
2.1.5 Summing up	38
2.2 Algebraic methods	39
2.2.1 Introduction to lattices	39
2.2.2 The algebraic representation of a logic	44
3 The propositional logic of mechanics	51
3.1 The logic of mechanical theories	51
3.1.1 Simple propositions	51

3.1.2	Complex propositions	54
3.1.3	Valuations	56
3.1.4	Logical connectives	58
3.1.5	Some properties of logic LM	60
3.1.6	Summing up	63
3.2	The algebraic structure of the logic	64
3.2.1	The structure of LM	64
3.2.2	The representation of LM_T	68
3.2.3	Summing up	69
4	States and measurement in mechanics	70
4.1	The states of a theory	70
4.1.1	What is a state?	70
4.1.2	Representing states and valuations	72
4.1.3	States and the logic of a theory	74
4.1.4	Summing up	77
4.2	The role of measurement	77
4.2.1	The logical role of measurement	77
4.2.2	The successor relation	80
4.2.3	Classical and non-classical succession	82
4.2.4	Compatibility	85
4.2.5	Summing up	88
5	The traditional analysis of probabilities	90
5.1	Introduction to Kolmogorov probabilities	90
5.1.1	Defining probabilities	90
5.1.2	Some properties of probabilities	93
5.2	The traditional analysis of classical mechanics	96
5.2.1	The event space	96
5.2.2	Probabilities and logic	97
5.3	The problem of quantum probabilities	99
5.3.1	The problem	99
5.3.2	Some reactions to the problem	101
6	The probabilities of mechanics	104
6.1	The new foundation for probabilities in mechanics	104
6.1.1	Predictive conditional probabilities	104
6.1.2	Some special cases	107
6.1.3	Other representations	109
6.1.4	Some properties of the probabilities	111
6.1.5	Summing up	115
6.2	The probabilities of classical mechanics	116
6.2.1	The absolute probability space	116
6.2.2	Some properties of classical probabilities	118
6.2.3	Summing up	121

6.3	The probabilities of quantum mechanics	122
6.3.1	Some general remarks	122
6.3.2	Some specific examples	125
6.3.3	Quantum sequential probabilities	129
6.3.4	Summing up	132
7	The modal logic of predictions	133
7.1	Introduction to modal logic	133
7.1.1	What is a modal logic?	133
7.1.2	'Possible worlds'	133
7.1.3	The normal modal systems	136
7.1.4	A more general analysis of modalities	137
7.2	A modal logic of mechanics	139
7.2.1	The modal extensions of LM_T	139
7.2.2	Modalities in mechanics	141
7.3	Von Neumann's 'Quantum logic'	143
7.3.1	The logical 'paradox'	143
7.3.2	The general argument	145
7.3.3	Reply to von Neumann	149
7.3.4	Summing up	154
8	Conclusions	156
8.1	Return to the paradoxes	156
8.1.1	Schrödinger's cat	156
8.1.2	EPR	158
8.1.3	The two-slit experiment	159
8.2	Bohr and Einstein	162
8.2.1	The logical interpretation	163
8.2.2	Bohr	164
8.2.3	Einstein	165
8.3	In conclusion	167
8.3.1	Logical remarks	167
8.3.2	Conclusion	170
	References	171
	Index	173
	Index of symbols	177