

Contents

Preface	vii
1. Zero	1
1.1 An Origin for Everything	2
1.2 The Genesis of Number	3
1.3 The Genesis of Algebra	9
1.4 Group Representations	14
1.5 Rewriting Nature	18
1.6 Quaternions and Vectors	24
2. Why Does Physics Work?	32
2.1 A Foundational Level	33
2.2 The Origin of Abstraction	35
2.3 Symmetry	36
2.4 The Meaning of the Conservation Laws	39
2.5 The Mathematical Structure of Physical Quantities	42
2.6 Where Does Dimensionality Come From?	45
2.7 A Group of Order 4	50
2.8 Noether's Theorem Revisited	54
2.9 Analytic Versus Synthetic	55
2.10 The Power of Analogy	58
2.11 The Nature of Reality	60
3. The Emergence of Physics	63
3.1 The Mathematical Character of Physics	63
3.2 The Algebra of Space, Time, Mass and Charge	64
3.3 The Dirac Algebra	69
3.4 The Creation of the Dirac State	72
3.5 The Nilpotent Dirac Equation	77
3.6 Uniqueness, Qubits and Quantum Computing	81
3.7 The Completeness of Mathematical Physics	82
3.8 Theoretical Computation	86

4.	Groups and Representations	88
4.1	The Dirac Equation and Quantum Field Theory	88
4.2	Reversals of Properties	91
4.3	The Dual Group and Higher Symmetries	93
4.4	A Broken Octonion	96
4.5	A Hierarchy of Dualities	99
4.6	Dimensionality	101
4.7	Symmetry Hierarchy	103
4.8	Colour Representation	105
4.9	3-D (Vector) Representation	107
4.10	Tetrahedral Representation	109
5.	Breaking the Dirac Code	111
5.1	Singularities and Redundancy	111
5.2	Redundancy in the Dirac Equation	113
5.3	Defragmenting the Dirac Equation	115
5.4	The Dirac 4-Spinor	118
5.5	The 4-Component Differential Operator	123
5.6	C-Linear Maps and Lifts	125
5.7	The Quaternion Form Derived from a Matrix Representation	127
5.8	Bilinear Covariants and the Dirac Lagrangian	131
5.9	Removing Redundancies in Relativistic Quantum Mechanics	133
5.10	Orthonormality of the Nilpotent Solutions of the Dirac Equation	134
6.	The Dirac Nilpotent	137
6.1	Spin	137
6.2	Helicity	139
6.3	Fermions and Bosons	141
6.4	Vacuum	146
6.5	<i>CPT</i> Symmetry	149
6.6	Baryons	151
6.7	Gluons and Exotic States	154
6.8	Parities of Bosons and Baryons	156
6.9	Supersymmetry and Renormalization	157
6.10	Annihilation and Creation Operators	160
6.11	The Quantum Field	161
6.12	The Nilpotent State	163
6.13	Nonlocality	164
6.14	BRST Quantization	166
7.	Nonrelativistic Quantum Mechanics and the Classical Transition	168
7.1	The Bispinor Form of the Dirac Equation	168
7.2	The Schrödinger Approximation	171
7.3	The Heisenberg Formulation of Quantum Mechanics	174

7.4	Heisenberg v. Schrödinger	175
7.5	The Quantum-Classical Transition	177
7.6	The Classical Limit	179
7.7	The Dirac Nilpotent Using Discrete Differentiation	182
7.8	Idempotent and Nilpotent Versions of Quantum Mechanics	185
7.9	A Fundamental Quantum Mechanical Duality	186
8.	The Classical and Special Relativistic Approximations	191
8.1	Linear Versus Orbital Dynamics	191
8.2	Scaling Relations	192
8.3	Special Relativity	195
8.4	The Significance of the Proper Time	199
8.5	The Nature of Classical Physics	203
8.6	Constructed Quantities	206
8.7	Classical Mechanics	207
8.8	Classical Electromagnetic Theory	212
9.	The Resolution of Paradoxes	218
9.1	Paradoxes Relating to Conservation and Nonconservation	218
9.2	Paradoxes Relating to Continuity and Discontinuity	222
9.3	Irreversibility and Causality	225
9.4	The Mass Frame and Zero-Point Energy	228
9.5	Two Versions of Relativity	232
9.6	Thermodynamics and the Arrow of Time	235
10.	Electric, Strong and Weak Interactions	239
10.1	The Dirac Equation in the Coulomb Field	240
10.2	Condensed Matter: The Kronig-Penney Model	246
10.3	The Helium Atom	248
10.4	$SU(3)$	250
10.5	The Quark-Antiquark and Three-Quark Interactions	252
10.6	Angular Momentum	258
10.7	The Weak Filled Vacuum	260
10.8	The Origin of the Higgs Mechanism	263
10.9	$SU(2)_L \times U(1)$	264
10.10	The Weak Interaction and the Dirac Formalism	266
10.11	The Higgs Mechanism for $U(1)$ and $SU(2)_L$	270
10.12	The Spherical Harmonic Oscillator	273
10.13	The Weak Interaction as a Harmonic Oscillator	277
10.14	A Strong-Electroweak Solution of the Dirac Equation	280
11.	QED and its Analogues	285
11.1	A Perturbation Expansion of the Dirac Equation for QED	285
11.2	Integral Solutions of the Dirac Equation	289

11.3	Renormalization	290
11.4	Green's Function Solution	293
11.5	The Propagator Method in Lowest Order	298
11.6	Electron Scattering	300
11.7	Strong and Weak Analogues	305
11.8	QFD Using Nilpotents	307
11.9	The Success of the Nilpotent Method	309
12.	Vacuum	310
12.1	Physics and Observables	310
12.2	Zero-Point Energy	312
12.3	The Weak Vacuum	313
12.4	The Strong Vacuum	315
12.5	The Electric Vacuum	316
12.6	The Gravitational Vacuum	318
12.7	The Casimir Effect	319
12.8	Berry's Geometric Phase	321
13.	Fermion and Boson Structures	324
13.1	The Charge Structures of Quarks and Leptons	324
13.2	A Unified Representation for Quarks / Leptons	327
13.3	Conservation of Charge Type and Conservation of Angular Momentum	329
13.4	Phase Diagrams for Charge Conservation	330
13.5	Quark and Lepton Charge Structures in Tabular Form	332
13.6	Mesons and Baryons	338
13.7	The Standard Model	339
13.8	A Pentad Structure for Charges and their Transitions	345
13.9	Lepton-Like Quarks	346
14.	A Representation of Strong and Weak Interactions	349
14.1	Charge Occupancy	349
14.2	Symmetries in a Matrix Representation	353
14.3	Constructing a Baryon	355
14.4	Constructing a Meson	358
14.5	Lepton Structures	359
14.6	The Electroweak Interaction Mechanism	360
14.7	The Production of Leptons	363
14.8	Electroweak Mixing	366
14.9	$SU(2)$ Transitions	367
14.10	The Higgs Coupling	369
14.11	The Mass Gap for Any Gauge Group	371

15. Grand Unification and Particle Masses	374
15.1 A Dirac Equation for Charge	375
15.2 $SU(5)$ Symmetry	378
15.3 The Grand Unification Group Generators	379
15.4 The Dirac Algebra Operators and $SU(5)$ Generators	382
15.5 Superspace and Higher Symmetries	386
15.6 Grand Unification and the Planck Mass	388
15.7 The Generation of Mass	394
15.8 The Higgs Model for Fermions	397
15.9 The Masses of Baryons and Bosons	398
15.10 The Masses of Fermions	405
15.11 The CKM Mixing	408
15.12 A Summary of the Mass Calculations	411
16. The Factor 2 and Duality	414
16.1 Duality and Physics	414
16.2 Kinematics and the Virial Theorem	415
16.3 Relativity	418
16.4 Spin and the Anomalous Magnetic Moment	422
16.5 The Linear Harmonic Oscillator	424
16.6 The Heisenberg Uncertainty Principle	426
16.7 Fermions and Bosons	426
16.8 Radiation Reaction	428
16.9 Supersymmetry and the Berry Phase	431
16.10 Physics and Duality	435
16.11 The Factor 2 and Electroweak Mixing	439
16.12 Alternative Dualities	440
16.13 Mathematical Doubling and the Self-Duality of the Dirac Nilpotent	442
17. Gravity and Inertia	444
17.1 The Continuity of Mass-Energy	445
17.2 The Speed of Gravity	448
17.3 What is General Relativity About?	449
17.4 General Relativity and Quantum Mechanics	452
17.5 The Schwarzschild Solution	455
17.6 Gravitational Redshift	457
17.7 The Gravitational Deflection of Electromagnetic Radiation	459
17.8 The Gravitational Time-Delay of Electromagnetic Radiation	461
17.9 Perihelion and Periastron Precession	463
17.10 The Inertial Correction	467
17.11 The Aberration of Space	470
17.12 Gravomagnetic Effects	472
17.13 A Linear Interpretation of the Gravitational Field	477

18. Dimensionality, Strings and Quantum Gravity	484
18.1 Discreteness and Dimensionality	484
18.2 Dimensionality and Chirality	486
18.3 '4-Dimensional' Space-Time	488
18.4 Proper Time and Causality	489
18.5 The Klein Bottle Analogy	490
18.6 A String Theory Without Strings	491
18.7 Twistor Representations	493
18.8 Quantum Gravitational Inertia	495
18.9 Calculation of Quantized Gravitational Inertia	499
19. Nature's Code	502
19.1 The Dirac Nilpotent as the Origin of Symmetry-Breaking	502
19.2 The Significance of the Pseudoscalar Term	505
19.3 Spin and Aggregation of Matter	509
19.4 Self-Organization of Matter	511
19.5 The Filled Weak Vacuum and the One-Handed Bias in Nature	513
19.6 The Idea of 3-Dimensionality	514
19.7 Application to Biology: DNA and RNA Structure	515
19.8 Transcription	516
19.9 Translation and Triplet Codons	517
19.10 Triplet Codons and the Dirac Algebra	518
19.11 The Five Platonic Solids	527
19.12 Fibonacci Numbers	529
19.13 Application of Geometrical Structures to DNA and Genetic Coding	532
19.14 Pentagonal Symmetry Within DNA	539
19.15 The Cube and the Harmonic Oscillator	550
19.16 The Rewrite Process as Nature's Code	552
19.17 The Unification of Physics and Biology	555
20. Nature's Rules	556
20.1 A Semantic Model of Computation	557
20.2 Scientific Perspectives on Computation	559
20.3 The Nilpotent Structure of the Universal Grammar	562
20.4 General Relativity and NQM Semantic Description	564
20.5 Analysis over the Surreals	565
20.6 The Heaviside Operator	567
20.7 Wheeler's Meaning Circuit	569
20.8 Anticipatory Computation and Other Ideas Supporting the NUCRS	571
20.9 A Boundary Condition and the Holographic Principle	573
20.10 Quantum Holography	574
20.11 The Bra and Ket Notation	577
20.12 The Universe as a Quantum Thermodynamic Engine	578
20.13 The Riemann Zeta Function	581

20.14 Galactic Structure	583
20.15 Quantum Thermodynamics and Evolution	585
20.16 DNA as a Rewrite System	590
20.17 Brains as Quantum Carnot Engines	595
20.18 Language and Universal Grammar	596
20.19 Nature's Process	599
21. Infinity	600
21.1 A Version of Mach's Principle	601
21.2 Gravity and Inertia	606
21.3 Cosmology and Physics	608
21.4 Information Loss and Radiation	610
21.5 A Numerological Coincidence?	611
21.6 Vacuum Acceleration and Radiation	613
21.7 The Concept of Creation	619
Appendix A Summary and Predictions	623
A.1 Summary of the Main Argument	623
A.2 Predictions	629
Appendix B The Infinite Square Roots of -1	633
References	639
Index	669