

# 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