Excursions in Computing Science: Table of Contents

T. H. Merrett*
McGill University, Montreal, Canada

August 2, 2021

Book 11d. Forces and Invariants Part IV. Quantum Field Theory: Matrix Quantum Mechanics
Book 11d. Forces and Invariants Part V. Functional Integrals
Book 11d. Forces and Invariants Part VI. Quantum Computing
Week 12. Memory and Programming Language: Recursion and Instantiation

Wk|Bk	Part	Note	Ex	Page	Topic
ii		01		001	**Powers.**
ii		02		001	**Trees**
ii		03		003	**Inverting trees.**
ii		04		004	**Properties of powers.**
ii		05		005	**Interest.**
ii		06		006	**Binomial coefficients.**
ii		07		007	**Factorials.**
ii		08		008	**Really big numbers.**
ii		09		014	**Really small numbers.**
ii			01	017	Perfect numbers
ii			15	019	**Golden ratio.**
ii			34	023	**Monotonic paths.**
ii			38	024	(Zeno's dichotomy paradox.)
ii			40	024	**Factorial trees.**
ii			41	024	**Choose trees.**
ii			42	025	**Ways trees.**
ii			47	026	Nine constellations.
ii			60	031	**Hypercubes.**
iii		01		001	**Base 10.**
iii		02		003	**Base 2.**
iii		03		004	**Base 3.**
iii		04		006	**Bases and powers.**
iii		05		006	**Rationals < 1.**
iii		06		007	**The Genetic Code.**
iii		07		008	**Polynomials.**
iii		08		009	**Multiplying polynomials.**
iii		09		010	**Polynomial division.**
iii		10		012	**Bases and polynomials**
iii			14	015	**Z-order**
iii			27	018	**Legendre polynomials.**
iii			27	018	**Hermite polynomials.**
iii			29	018	**Modular arithmetic.**
iv		01		001	**Matrix multiplication.**
iv		02		002	**Vectors.**
iv		03		003	**Identity matrix.**
iv		04		003	**Matrix inverse.**
iv		05		004	**Vectors in space.**
iv		06		006	**Positions and intervals.**
iv		07		006	**Transforming space.**
iv		08		007	**Rotations.**
iv		09		008	**Shear.**
iv		10		009	**Diagonalizing matrices.**
iv			09	014	**Cosine and sine.**
iv			10	017	**2-dimensional numbers**
iv			11	017	**Three-dimensional rotations.**
iv			16	019	Velocities in timespace.
iv			17	021	**Reflections, etc.**
iv			21	023	**Projection and reflection.**
iv			22	024	**Diagonalizing matrices.**
iv			23	027	**Array addressing.**
iv			24	028	**Simplex arrays.**

Wk|Bk	Part	Note	Ex	Page	Topic
v	1	01		001	Solving $x^2 - x - 1 = 0$
v	1	02		001	Picture of $x^2 - x - 1 = 0$
v	1	03		002	**Cartesian Plane.**
v	1	04		004	**Symmetry.**
v	1	05		004	**Functions.**
v	1	06		006	**Zeros of a function.**
v	1	07		006	**Symmetry, again.**
v	1	08		007	**Slopes.**
v	1	09		010	**Slopes of curves.**
v	1	10		012	**Centering.**
v	1	11		013	**Limits.**
v	1	12		015	**Back to the zeros of $\frac{5}{2}x^2 - \frac{1}{2}x - 2$.**
v	1	13		016	**Square roots.**
v	1	14		018	**Self-slope.**
v	1	15		020	**Infinite series.**
v	1	16		021	**Programming the infinite series.**
v	1	17		023	**Slope equations.**
v	1	18		024	**Ninety-degree rotations.**
v	1	19		026	**Two-dimensional numbers.**
v	1	20		027	**Slope of c and s.**
v	1	21		028	**Connecting with slope equations.**
v	1		06	029	**Mensuration**
v	1		08	030	**Inverses.**
v	1		09	031	**Radians.**
v	1		10	031	**Rotation generators.**
v	1		11	032	**3D rotation generators.**
v	2	01		001	**Cube root of 8.**
v	2	02		002	**Slope.**
v	2	03		002	**Approximations.**
v	2	04		003	**Slope of cubic.**
v	2	05		003	**The root.**
v	2	06		004	**Square roots.**
v	2	07		004	**Antislopes.**
v	2	08		005	**Areas.**
v	2	09		008	**Volumes.**
v	2	10		009	**Antislopes and areas.**
v	2	11		010	**The Fundamental Theorem of Calculus.**
v	2		01	011	**Throwing balls: parabola and square roots.**
v	2		04	013	**Pythagoras.**
v	2		11	016	**Gini and IGE.**
v	2		11	018	**Least squares fit.**
v	2		11	019	**Minimizing.**
01		01		001	One polarizing filter
01		02		002	Two polarizing filters
01		03		003	Theory
01		04		004	Cosine
01		05		005	A third polarizing filter
01		06		005	Theory predicts
01		07		007	Theory predicts wrong?
01		08		007	Two polarizing filters again
01		09		008	Testing theory
01		10		008	Theory fixed
01		11		009	**Algorithm for scientific theories.**

Wk|Bk	Part	Note	Ex	Page	Topic
01			01	010	**Quantitative thinking is important.**
01			03	010	**Measuring angles.**
01			06	011	(Trig. and triangles)
01			07	011	Eugene's Clock
01			08	012	**Celtic knots and other fun with cos and sin.**
01			14	016	**Useful cos and sin.**
01			15	017	Trigonometry can help us locate the stars.
01			16	021	**Hyperspheres.**
01			19	022	**Can quantum physics be made more complete?**
01			20	024	**Quantum key distribution.**
02		01		001	Operators - polarizing light
02		02		002	Light beam as vector
02		03		002	Horizontal component
02		04		002	Component at angle
02		05		003	Vector multiplication
02		06		005	Polarizing filter as projection operator
02		07		005	Three projections
02		08		006	c^2, s^2, cs
02		09		007	two rotations, Pythagoras
02		10		008	product of functions, sum of arguments
02			02	009	values for cos, sin
02			16	011	linear operator
02			17	012	ruler and compass
03		01		001	time and distance
03		02		001	speed
03		03		001	timespace, Galileo, Stan and Trav
03		04		003	maximum speed
03		05		004	modifying Galileo, eigenvalues
03		06		005	matrix from fixed directions, eigenvalues
03		07		005	unit determinant
03		08		006	**Digression on determinants.**
03		09		007	Lorentz transformation
03		10		009	**Using the Lorentz transformation.**
03		11		010	**Physical principles behind special relativity.**
03			18	012	time dilation
03			19	013	**Lorentz ($c \neq 1$).**
03			20	013	**The weird fizzmezh matrices.**
04		01		001	Matrices as numbers?
04		02		001	One-dimensional numbers and 90-degree rotation
04		03		001	90-degree rotation as sqrt(-1)
04		04		002	cos + sqrt(-1)sin as rotation
04		05		002	x + sqrt(-1)y as vector
04		06		002	sqrt(-1) as "imagine that!", 2-dimensional numbers
04		07		003	formal properties of numbers
04		08		003	Adding 2-numbers
04		09		003	Multiplying 2-numbers
04		10		004	**Turtle graphics.** Total Turtle Turning

Wk|Bk	Part	Note	Ex	Page	Topic
04			01	006	De Moivre
04			03	007	Logo programming language
04			04	007	Army ant Eciton burchellie bivouacs
04			05	007	Treasure Island
04			06	008	Interpreting numbers
04			07	008	Moving parabolas and their shadows
04			09	010	**Roots of unity.**
04			10	010	**Conjugates.**
04			11	010	shear and 2-numbers
04			12	010	eigenvalues of rotation
04			13	011	anticommuting matrices
04			14	011	Fourier transform inverse
04			15	011	field axioms
04			16	011	ruler and compass cannot trisect angles
04			18	011	**Field trip** modulo arithmetic, solving by radicals
04			21	014	ring axioms
04			22	014	**"Symmetric polynomials".**
05		01		001	Amplitudes as 2-numbers
05		02		001	**Photons**
05		03		002	Feynman's rules
05		04		002	Probabilities for Young's double slit
05		05		003	Wavelength
05		06		004	Trigonometry for double slit
05		07		005	Light travels in straight lines
05		08		007	Two ways to collide alpha-particles
05		09		008	Two ways to collide electrons - new Feynman rule - bosons, fermions
06		01		001	**States.**
06		01		001	Two polarization states of light
06		02		001	Two polarization states of electrons
06		03		002	Euler angles, transformation matrix
06		04		003	Half angles
06		05		003	Pauli matrices
06		06		003	Special Euler angles
06		07		004	Transforming amplitudes
06		08		004	Two q-bits
06		09		004	Symmetric and antisymmetric states
06		10		005	Spin-1 and polarized light
06		11		005	Circular to linear polarization
06		12		006	Linear polarization rotates in two dimensions
06		13		006	Lightspeed eliminates a third dimension
06		14		007	**Fermions and Bosons.**
06			11	008	**Spin 3/2.**
06			12	010	**Spin 2.**
06			15	010	The periodic table

Wk|Bk	Part	Note	Ex	Page	Topic
08		01		001	Importance of a web page - cycles
08		02		002	Importance of a web page - no cycles
08		03		003	Add equal columns of small numbers as source vector
08		04		004	Linear equations - **Elementary row operations**
08		02		005	**Gauss elimination**
08		06		006	**3D for 2D graphics** - tetrahedron to triangle to collinear
08		07		007	Sketchpad example 1 (linear constraint)
08		08		008	Sketchpad example 2 (nonlinear constraint)
08		09		010	**Iterate!**
08		10		011	**Underdetermined equations** - Sketchpad example 3 (point collinear with li
08		11		012	Minimize subject to constraint
08		12		013	**Overdetermined equations**
08		13		014	**Overdetermined equations**
08			10	017	Factor analysis/Principal components analysis in the measurement of personal
08			14	021	**Null spaces and stoichiometry.**
08			15	024	**Quadratic forms and stability.**
08			16	025	Binomial coefficients
08			28	027	**Slopes of cos and sin.**
08			38	032	Surveying
08c	1	01		001	Triangle symmetry
08c	1	02		002	Generating reflections
08c	1	03		002	Permutation notation
08c	1	04		003	Group properties
08c	1	05		003	Reflecting rotations, rotating reflections
08c	1	06		004	Invariant sets
08c	1	07		005	Invariant (normal) subgroups
08c	1	08		005	Matrix invariant sets share eigenvalues, determinant, trace
08c	1	09		006	Other representations - trivial, direct, permutation
08c	1	10		007	Using traces to block-diagonalize a whole matrix representation
08c	1	11		008	Regular representation
08c	1	12		010	**Molecules** 1D
08c	1	13		012	Triangle molecule
08c	1	14		017	**Greenhouse gases** CO_2
08c	1	15		018	**Greenhouse gases** H_2O
08c	1	16		019	**Tetrahedron.**
08c	1	17		024	**Hexa/Octahedra.**
08c	1	18		025	**Dodeca/Icosahedra.**
08c	1		06	028	Car wheels
08c	1		37	031	**Spring constants.**
08c	1		53	034	**Symmetric field trip - Galois and the quintic**
08c	2	19		002	**Infinite groups**
08c	2	20		003	**1D crystals**, gratings, CDs
08c	2	21		006	**2D crystals**
08c	2	22		011	**2D waves**
08c	2	22		012	**Periodic boundary conditions**
08c	2	23		015	**Brillouin zone.**
08c	2	24		016	**Non-translational crystal symmetries.**
08c	2	25		016	**Wallpaper groups.**
08c	2		03	022	poetic symmetry
08c	2		04	023	CDs and DVDs
08c	2		13	023	**Dot product.**
08c	2		23	026	**Wallpaper groups.**
08c	2		38	028	**Periodic interactions**, vernier, moiré

Wk|Bk	Part	Note	Ex	Page	Topic
08c	3	26		002	**Continuous groups.**
08c	3	27		004	**Spherical symmetry.**
08c	3	28		006	**Commutator algebra.**
08c	3	29		007	**Representations of the spherical group.**
08c	3	30		013	**Spherical harmonics**, slope rules
08c	3	31		020	**Atomic physics.**
08c	3		06	027	Angular momentum
08c	3		09	027	**Kepler II.**
08c	3		12	028	Half-Pauli matrices
08c	3		16	028	Commutator algebra, Lie groups
08c	3		22	029	Slope rules, product rule, chain rule
08c	3		35	030	**Bohr atom.**
08c	3		36	031	**Kepler III**
08c	3		37	032	**Conic sections.**
08c	3		38	034	**Kepler I.**
08c	4	32		002	**SU(2) formal and informal.**
08c	4	33		006	**SU(3).**
08c	4	34		013	**Isospin and quarks**
08c	4	35		016	**Symmetry and Conservation; Complementary Quantities**
08c	4	36		017	**Symmetry and Conservation; Energy**
08c	4	37		020	**Principle of Stationary Action.**
08c	4	38		028	**Symmetry and Conservation; Noether's Theorem**
08c	4	39		030	**The Hamiltonian and Schrödinger's Equation**
08c	4		19	037	**Billiards.**
08c	4		20	040	**Molecules**
08c	4		21	042	**Forces and deformations.**
08c	4		22	047	**Spring oscillators.**
08c	4		25	049	Potential energy
08c	4		37	050	**Legendre transformation.**
08c	4		41	052	Dirac equation
08d	1	01		001	**The rocket equation.**
08d	1	02		004	**Specific impulse.**
08d	1	03		004	**Fuels.**
08d	1	04		010	**Multistage rockets.**
08d	1	05		010	**Thrust.**
08d	1	06		011	**Photon sails.**
08d	1	07		014	**Solar wind.**
08d	2	08		001	**Ideology.**
08d	2	09		003	**Circles and ellipses.**
08d	2	10		005	**Pythagoras.**
08d	2	11		006	**Circular orbits.**
08d	2	12		008	**Finding and using GM_{Earth}.**
08d	2	13		009	**Weighing Earth and Sun.**
08d	2	14		010	**The Solar planets.**
08d	2	15		011	**Transfer orbits.**
08d	2	16		012	**Velocities in elliptical orbits.**
08d	2	17		014	**Momentum and kinetic energy.**
08d	2	18		016	**Potential energy.**
08d	2	19		017	**Delta-V for orbit changes.**
08d	2	20		018	**Surface to LEO.**
08d	2	21		019	**Travelling the solar system.**
08d	2	22		025	**Launch windows.**
08d	2	23		027	**Conic sections.**
08d	2	24		031	**Gravity assist.**
08d	2	25		032	**Resonances.**
08d	2	26		037	**Tides.**
08d	2	27		042	**The Lagrange points.**

Wk|Bk	Part	Note	Ex	Page	Topic
08d	3	28		002	**Economics.**
08d	3	29		006	**Microgravity.**
08d	3	30		007	**Radiation.**
08d	3	31		012	**Space debris.**
08d	3	32		016	**Space elevator.**
08d	3	33		020	**Ecology.**
08d	3	34		022	**Population.**
08d	3	35		023	**Genetics.**
08d	3	36		025	**History.**
08d	3	37		026	**Self-reproducing probes.**
08d	3	38		030	**"Where Are They?"**
08d	4	39		002	**Speeds.**
08d	4	40		005	**Extinctions.**
08d	4	41		006	**Herd science.**
08d	4	42		007	**Climate.**
08d	A	43		002	**Trigonometry.**
08d	A	44		005	**Integral calculus.**
08d	A	45		010	**Differential calculus.**
09		01		001	2D numbers give 5D vector space
09		02		002	Fourier transform, FT
09		03		004	Approximating function using important frequencies only
09		04		005	Joint Photographic Experts Group, JPEG
09		05		007	**The fast Fourier transform**, FFT
09		06		009	**Divide and Conquer**
09		07		010	**The Uncertainty Principle**
09		08		012	**Compression and Content**
09			14	014	**FFT again.**
09			17	015	**Modified inverse FT.**
09			18	017	**FT with vector k, ℓ.**
09			19	019	**Continuous FT.**
09			20	020	**Artefacts of sampling.**
09			23	022	**Two-dimensional discrete Fourier transform**
09			24	022	**Digital signal processor, DSP filters.**
09			25	033	Tachyons faster than light

Wk|Bk	Part	Note	Ex	Page	Topic
09c	2		10	064	**First simulation.**
09c	2		11	064	**Doves and hawks.** (A kinetic theory of conflict, 1.)
09c	2		12	066	**Dominance.** (A kinetic theory of conflict, 2.)
09c	2		13	069	**Hierarchies.**
09c	2		14	071	**Cycles.**
09c	2		19	074	**Maxwell distribution.**
09c	2		29	075	**Sackur-Tetrode equation.**
09c	2		32	076	**Local inverses of functions.**
09c	2		33	077	**Complementary variables.**
09c	2		45	078	**Causality.**
09c	2		46	079	Emergence
09c	3	23		002	**Correlation.**
09c	3	24		012	**Collision theory.**
09c	3	25		016	**Mobility, diffusivity and Brownian motion.**
09c	3	26		019	**Three potentials and dissipation.**
09c	3	27		022	**Active transport and biochemistry.**
09c	3	28		024	**Combined transport.** Onsager relations.
09c	3		05	027	**Least squares filter.**
09c	3		19	029	**Kirchhoff circuits.**
09c	3		20	030	**Resistors in series and parallel.**
09c	3		21	031	**Kirchhoff lattices; relations and operators.**
09c	3		24	037	**Viscosity and heat conduction.**
09c	3		25	041	**"Ohm's law" for viscosity.**
09c	3		26	041	**Elasticity and viscosity: stress, strain and flow tensors.** Poisson's ratio
09c	3		26	044	**Hookean solid.**
09c	3		26	046	**Newtonian liquid.**
09c	3		26	047	**Principal axes.**
09c	3		27	048	**Lattice statics and dynamics.**
09c	3		30	056	**Chemical kinetics and differential equations.**
09c	3		30	062	**Coupled linear first-order differential equations.**
09c	3		31	075	**Chemistry in the language of physics.**
09c	4	29		002	**Phase transitions.**
09c	4	30		003	**Phase transitions in random graphs.**
09c	4	31		009	**Point-to-point resistance in a network.**
09c	4	32		012	**Van der Waals.**
09c	4	33		016	**Sublimation.**
09c	4	34		018	**Ferromagnets.**
09c	4	35		020	**Particle individuality and Bose-Einstein condensation.**
09c	4		06	027	**Percolation.**
09c	4		07	027	**Point of inflection.**
09c	4		21	029	**Infinities.**
09c	4		22	029	**Gibbs' paradox.**
09c	4		23	030	**Ovations.**
09c	4		24	033	social phase transitions
09c	4		25	033	**Power laws.**
09c	4		26	033	**Self-Organized Criticality.**
09c	4		27	035	Ising model.
10		01		001	Axioms of an algebra
10		02		002	Boolean algebra of two elements
10		03		003	Implication operator
10		04		004	Sixteen binary operators
10		05		005	Switching circuits; halfadder, fulladder
10		06		007	**Reversibility** controlled-not, controlled-exchange
10		07		010	Operators as matrices
10		09		011	**Appendix Binary Arithmetic**

Wk|Bk	Part	Note	Ex	Page	Topic
10			11	013	**More than one kind of infinity**
10			12	015	Continued fractions
10			26	017	Analogic reasoning
10			34	019	Sets and probability
10			36	036	Birthday paradox
10			37	020	Genetic overlap
10			52	021	**Matrix logic.**
10			53	024	**xor** and **and**.
10			54	026	**C^kN circuits.**
10			55	026	**Basic matrices for logic.**
10			60	028	**Euclid's Elements.**
11		01		001	**Memory** flipflop, feedback automata
11		02		005	**Control** thermostat
11		03		006	Electric blanket control
11		04		008	**Biology** the lac operon of E.coli, gene expression, attractors
11		05		009	**Language** parsing by finite automaton
11		06		011	evaluation by actions
11		07		013	nested parentheses and pushdown automaton
11		08		014	evaluation by reverse Polish; shunting
11		09		016	automata hierarchy
11			22	018	attractors
11			26	019	attractors
11			29	019	tipping point
11			30	019	gene expression, microarrays
11			35	021	rich and poor
11			37	022	**Traffic memory.**
11			40	023	concrete poetry
11			48	025	Turing machine
11c	1	01		001	**Fields and slopes.**
11c	1	02		002	**"Reality" and coordinates.**
11c	1	03		005	**Index notation and tensors.**
11c	1	04		008	**Protors.**
11c	1	05		011	**The protor calculator 1.**
11c	1	06		013	**Divergence and Curl.**
11c	1	07		018	**Classical gravity.**
11c	1	08		023	**Gypsum coordinates.**
11c	1	09		029	**The metric.**
11c	1	10		031	**Fields in gypsum.**
11c	1	11		035	**Polar coordinates.**
11c	1	12		037	**The affine connection.**
11c	1	13		041	**Parallel transport and geodesics.**
11c	1	14		043	**Absolute slopes.**
11c	1	15		046	**Gradient, divergence and curl with absolute slope.**
11c	1	16		049	**Spherical polar coordinates.**
11c	1	17		053	**Curvature.**
11c	1	18		061	**Negative curvature.**
11c	1	19		065	**The Ricci tensor.**
11c	1	20		067	**More protor calculator.**

Wk|Bk	Part	Note	Ex	Page	Topic
11c	1		01	075	**Slopes commute?**
11c	1		13	077	**Newton's constant.**
11c	1		14	077	**Gauss' law** for volume and surface integrals
11c	1		15	077	**Message through the Earth.**
11c	1		16	079	**Falling traffic lights**
11c	1		23	081	**Levi-Civita symbol, alternating tensors.**
11c	1		24	083	**Physical tensors.**
11c	1		25	084	**Orthonormal polars.**
11c	1		36	087	**Hotplate geometry.**
11c	1		37	090	**Absolute slope and curvature.**
11c	1		38	090	**Bianchi identities.**
11c	1		39	091	**Divergence-free curvature.**
11c	1		40	092	**Number of components of the curvature tensor.**
11c	1		41	092	**Angular excess at fixed latitude.**
11c	1		42	096	**Local flatness.**
11c	1		43	099	**The boundary of boundary is zero.**
11c	1		46	100	**Curvature of lines.**
11c	1		49	104	**What functions for ch, sh?**
11c	1		51	106	**Hyperboloid.**
11c	1		52	107	**Paraboloid.**
11c	2	22		002	**Curved timespace.**
11c	2	23		005	**Gravitational redshift.**
11c	2	24		009	**Spherically symmetric gravity.**
11c	2	25		011	**Schwarzschild orbits and black holes.**
11c	2	26		016	**Rotationally symmetric gravity.**
11c	2	27		019	**Kerr orbits and black holes.**
11c	2	28		026	**Tides.**
11c	2	29		028	**Light orbits.**
11c	2	30		030	**The source of gravity.**
11c	2	31		033	**Cosmology.**
11c	2	32		037	**Negative pressure and dark energy.**
11c	2	33		039	**Gravitational irreversibility.**
11c	2	34		043	**Alternatives to geometry.**
11c	2		02	048	**Schwarzschild metric.**
11c	2		09	049	**The ergosphere.**
11c	2		24	052	**Newtonian limit.**
11c	2		25	052	**Inflation.**
11c	2		28	053	**Negative energy; warp drives.**
11c	2		29	056	**Negative mass.**
11c	2		30	056	**Blandford-Znajek mechanism.**
11c	2		32	056	**Gravitational waves.**
11d	1	01		001	**Central Forces.**
11d	1	02		004	**Gravity vs. Electricity.**
11d	1	03		004	**Energy and momentum scales.**
11d	1	04		008	**Divergence, gradient and** $\vec{\text{div}}$ $\vec{\text{grad}}$**.**
11d	1	05		009	**Electrodynamics departs from gravitation.**
11d	1	06		013	**Invariants, cross-products and convention.**
11d	1	07		019	**Electromagnetic waves.**
11d	1		04	022	**Gauss' law** for fields from charge.
11d	1		09	022	**Visualizing magnetic fields.**

Wk|Bk	Part	Note	Ex	Page	Topic
11d	2	08		001	**Partial Slope Equations; Laplace's Equation.**
11d	2	09		007	**The Wave Equation.**
11d	2	10		010	**The Schrödinger Equation I; Physics.**
11d	2	11		013	**The Schrödinger Equation II; Animating in 1D.**
11d	2	12		019	**The Schrödinger Equation III; Animating in 2D.**
11d	2		04	024	**Stability** of numerical solutions of the wave equation.
11d	2		05	025	**The Hamiltonian.**
11d	2		07	026	**Dispersion relations.**
11d	3	13		001	**The electromagnetic Schrödinger equation.**
11d	3	14		003	**Simulating a charged wavepacket moving near a current.**
11d	3	15		006	**Links with geometry.**
11d	3	16		008	**Local action versus action-at-a-distance.**
11d	3	17		009	**Other symmetries, other forces.**
11d	3		01	012	**Aharanov-Bohm effect.**
11d	3		03	013	**Maxwell's tensor and equations.**
11d	3		04	013	**Gauge theory.**
11d	3		06	014	**Abelian and non-Abelian symmetries.**
11d	3		07	016	**Goldstone and Higgs mechanisms.**
11d	3		08	020	**Quarks and vacuum.**
11d	4	18		001	**Introduction to Quantum Fields.**
11d	4	19		008	**Small matrices.**
11d	4	20		011	**Tensor products.**
11d	4	21		014	**Spin.**
11d	4	22		018	**Vectors and spinors.**
11d	4	23		021	**Multiple and independent systems.**
11d	4	24		024	**A simple field.**
11d	4	25		028	**The Yukawa potential.**
11d	4	26		031	**Perturbation approximations.**
11d	4	27		033	**Fermions.**
11d	4	28		035	**Slopes and antislopes of 2D numbers, etc.**
11d	4	29		042	**Charge conservation and antimatter.**
11d	4	30		045	**Relativistic quantum field theory redux, so far.**
11d	4		02	046	**Heisenberg uncertainty.**
11d	4		03	046	**More uncertainty.**
11d	4		06	048	**Sphere of reflections.**
11d	4		07	049	**Density matrices and inverse tensor product.**
11d	4		08	049	**Certainty and entanglement.**
11d	4		09	050	**Can quantum physics be made more complete? (Part II).**
11d	4		26	054	**Tensor product transposes.**
11d	4		31	054	**Hermitian transposes of reflections, etc.**
11d	4		33	055	**Slopes of Clifford functions.**
11d	5	31		002	**Fermions.**
11d	5	32		005	**Functionals.**
11d	5	33		008	**Gaussian integrals.**
11d	5	34		013	**Diagrams and QED.**
11d	5	35		016	**Chirality and electroweak.**
11d	5	36		023	**Green's functions.**
11d	5	37		030	**Propagators.**
11d	5		03	034	**Programming path integrals.**
11d	5		06	035	**Matrix Gaussians.**
11d	5		09	036	**Even moments.**
11d	5		14	037	**Current from faze invariance.**
11d	5		22	038	**Huygens 3D.**
11d	5		25	038	**Feynman's program Hamiltonian.**

Wk|Bk	Part	Note	Ex	Page	Topic
11d	6	38		003	**Quantum Computing.**
11d	6	38		004	Quantum Computing **Binary gates.**
11d	6	38		008	Quantum Computing **Measurement.**
11d	6	38		012	Quantum Computing **Ternary gates.**
11d	6	39		012	**Binary Fourier transform.**
11d	6	40		013	**Quantum Fourier transform.**
11d	6	41		015	**Finding periods.**
11d	6	42		017	**Quantum key distribution.**
11d	6	43		018	**No cloning.**
11d	6	44		019	**Database search.**
11d	6	45		024	**Detecting and correcting errors.**
11d	6	46		028	**Nonlocality; Einstein-Podolsky-Rosen.**
11d	6	47		029	**Building a quantum computer.**
11d	6		07	033	**Implement swap gate.**
11d	6		10	034	**Representing functions.**
12		01		001	**Recursion.** Define "ancestor" in terms of "parent".
12		02		001	**Precedence without parentheses**
12		03		002	**Fractals**
12		04		003	**Mathematical induction.**
12		05		004	**Recursion.** Programming languages.
12		06		004	**L-systems**
12		07		006	**Instantiation.**
12		08		007	Copying state.
12			07	009	Peano curve
12			13	010	Euler's formula, edges, faces, vertices
12			14	010	*Hexagonal numbers*
12			18	012	**Calculus.**
12			19	017	**Continuity.**
12			20	019	**Series.** Binomial coefficients.
12			28	021	Fractional dimension