

# Excursions in Computing Science: Keyword-in-context Index

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July 23, 2019

Keyword	W B	P	N E	Pag	Topic	(W B is week book, P is part, N E is note exc)
abelian	11d	3	E06	014	Abelian and non-Abelian symmetries.	
action-at-a-distance	11d	3	N16	008	Local action versus action-at-a-distance.	
active transport	09c	3	N27	022	Active transport and biochemistry.	
adding	04		N08	003	Adding 2-numbers	
affine connection	11c	1	N12	037	The affine connection.	
aggregates	09c	1	N04	007	Aggregates: the moments of distributions.	
aharanov-bohm	11d	3	E01	012	Aharonov-Bohm effect.	
al jabr	i		E44	025	Al jabr	
alpha-particles	05		N08	007	Two ways to collide alpha-particles	
amplitudes	05		N01	001	Amplitudes as 2-numbers	
amplitudes	06		N07	004	Transforming amplitudes	
analogic reasoning	10		E26	017	Analogic reasoning	
ancestor	12		N01	001	Recursion. Define "ancestor" in terms of "parent".	
and	10		E53	024	{\bf xor} and {\bf and}.	
angle	02		N04	002	Component at angle	
angles	01		E03	010	Measuring angles.	
angles	04		E16	011	ruler and compass cannot trisect angles	
angular excess	11c	1	E41	092	Angular excess at fixed latitude.	
angular momentum	08c	3	E06	027	Angular momentum	
annihilation	07c		E41	045	Creation and Annihilation.	
anti-pythagoras	07a		N05	003	Anti-Pythagoras	
anticommuting	04		E13	011	anticommuting matrices	
antislope	09c	1	E43	061	Continuous distributions by antislope	
antislopes	09c	1	E22	045	Notation, integrals and antislopes	
antislopes	11d	4	N28	035	Slopes and antislopes of 2D numbers, etc.	
antislopes	v	2	N07	004	Antislopes.	
antislopes	v	2	N10	009	Antislopes and areas.	
antisymmetric states	06		N09	004	Symmetric states and antisymmetric states	
approximate	i		E45	026	Approximate arithmetic	
approximating function	09		N03	004	Approximating function using important frequencies only	
approximation	i		E46	027	Brocot fractional approximation	
approximations	v	2	N03	002	Approximations.	
areas	07c		N06	006	Vectors and Areas and .. All Together	

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areas	v	2	N08 005	Areas.
areas	v	2	N10 009	Antislopes and areas.
arguments	02		N10 008	product of functions, sum of arguments
army ant	04		E04 007	Army ant Eciton burchellie bivouacs
array	iv		E23 027	Array addressing.
arrays	iv		E24 028	Simplex arrays.
ascendency	09c	1	E51 072	Ascendency.
ascendency	09c	1	E53 077	Maximizing ascendency.
atomic physics	08c	3	N31 020	Atomic physics.
attractors	11		E22 018	attractors
attractors	11		E26 019	attractors
attractors	11		N04 008	Biology: the lac operon of E.coli, gene expression, attract
automata	11		N01 001	Memory: flipflop, feedback automata
automata hierarchy	11		N09 016	automata hierarchy
automaton	11		N05 009	Language: parsing by finite automaton
automaton	11		N07 013	nested parentheses and pushdown automaton
axial vectors	07c		N05 005	Twirl and area are " pseudovectors" or "axial vectors"
axioms	04		E15 011	field axioms
axioms	04		E21 014	ring axioms
axioms	10		N01 001	Axioms of an algebra
baby ecologies	09c	1	E52 074	A playpenful of baby ecologies.
base 10	iii		N01 001	Base 10.
base 2	iii		N02 003	Base 2.
base 3	iii		N03 004	Base 3.
bases	iii		N04 006	Bases and powers.
bases	iii		N10 012	Bases and polynomials
bianchi identities	11c	1	E38 090	Bianchi identities.
big numbers	ii		N08 008	Really big numbers.
billiards	08c	4	E19 037	Billiards.
binary arithmetic	10		N09 011	Appendix Binary Arithmetic
binary gates	11d	6	N38 004	Quantum Computing Binary gates.
binomial coefficients	08		E16 025	Binomial coefficients
binomial coefficients	12		E20 019	Series. Binomial coefficients.
binomial coefficients	ii		N06 006	Binomial coefficients.
biochemistry	09c	3	N27 022	Active transport and biochemistry.
biology	11		N04 008	Biology: the lac operon of E.coli, gene expression, attract
birthday paradox	10		E36 036	Birthday paradox
black boxes	09c	1	E59 078	Black boxes.
black holes	11c	2	N25 011	Schwarzschild orbits and black holes.
black holes	11c	2	N27 019	Kerr orbits and black holes.
blandford-znajek	11c	2	E30 056	Blandford-Znajek mechanism.
bohr atom	08c	3	E35 030	Bohr atom.
boltzmann distribution	09c	2	N14 016	The Boltzmann distribution and Maxwell distribution.
boolean algebra	10		N02 002	Boolean algebra of two elements
bose-einstein condensat	09c	4	N35 020	Particle individuality and Bose-Einstein condensation.
bosons	05		N09 008	Two ways to collide electrons - new Feynman rule - bosons,
bosons	06		N14 007	Fermions and Bosons.
boundary of a boundary	11c	1	E43 099	The boundary of a boundary is zero.
brillouin zone	08c	2	N23 015	Brillouin zone.
brocot	i		E46 027	Brocot fractional approximation
brocot	i		E47 027	Better than Brocot: continued fractions.
brownian motion	09c	3	N25 016	Mobility, diffusivity and Brownian motion.
calculus	12		E18 012	Calculus.
calculus	v	2	N11 010	The Fundamental Theorem of Calculus.
cancellation	i		E44 025	The mystery of cancellation.
car wheels	08c	1	E06 028	Car wheels

carnot	09c	2	N22	057	Carnot's reversible heat engine, second law of thermodynamics.
cartesian plane	v	1	N03	002	Cartesian Plane.
causality	09c	2	E45	078	Causality.
celtic knots	01		E08	012	Celtic knots and other fun with cos and sin.
centering	v	1	N10	012	Centering.
central forces	11d	1	N01	001	Central Forces.
centre-of-mass	07a		N12	006	Centre-of-mass reference frame
certainty	11d	4	E08	049	Certainty and entanglement.
chain rule	08c	3	E22	029	Slope rules, product rule, chain rule
chemical kinetics	09c	3	E30	056	Chemical kinetics and differential equations.
chemistry	09c	3	E31	075	Chemistry in the language of physics.
chesapeake clams	09c	1	E49	070	Mutual information from Chesapeake clams.
chirality	11d	5	N35	016	Chirality and electroweak.
choose	ii		E41	024	Choose trees.
church-turing	07b		N01	001	Strong Church-Turing thesis
circular polarization	06		N11	005	Circular polarization to linear polarization
CkN circuits	10		E54	026	C <sup>k</sup> N circuits.
clifford "numbers"	07c		E38	031	Matrix representations of Clifford "numbers".
clifford algebra	07c		E37	031	Factoring sums and differences of squares by Clifford algebra
clifford algebra	07c		E40	038	Spin and Clifford Algebra.
clifford functions	11d	4	E33	055	Slopes of Clifford functions.
cloning	11d	6	N43	018	No cloning.
CO2	08c	1	N14	017	Greenhouse gases: CO <sub>2</sub>
co-ignorance	09c	1	N10	031	Correlation and co-ignorance.
collision	09c	3	N24	012	Collision theory.
collisions	09c	2	N12	001	A gas simulation 1: the collisions
combined transport	09c	3	N28	024	Combined transport. Onsager relations.
commutator algebra	08c	3	E16	028	Commutator algebra, Lie groups
commutator algebra	08c	3	N28	006	Commutator algebra.
commute	11c	1	E01	075	Slopes commute?
compass	02		E17	012	ruler and compass
complementary quantities	08c	4	N35	016	Symmetry and Conservation: Complementary Quantities
complementary variables	09c	2	E33	077	Complementary variables.
component	02		N03	002	Horizontal component
component	02		N04	002	Component at angle
compression	09		N08	012	Compression and Content
conditional distributions	09c	1	N11	034	Conditional distributions and ignorance.
conflict	09c	2	E11	064	Doves and hawks. (A kinetic theory of conflict, 1.)
conflict	09c	2	E12	066	Dominance. (A kinetic theory of conflict, 2.)
conic sections	08c	3	E37	032	Conic sections.
conjugates	04		E10	010	Conjugates.
conservation	11d	4	N29	042	Charge conservation and antimatter.
conserved	07a		N10	005	Energentum is conserved.
constant sums	09c	1	E46	068	Geometrical interpretations of constant sums.
constellations	ii		E47	026	Nine constellations.
continued fractions	10		E12	015	Continued fractions
continued fractions	i		E47	027	Better than Brocot: continued fractions.
continuity	12		E19	017	Continuity.
continuous groups	08c	3	N26	002	Continuous groups.
control	11		N02	005	Control: thermostat
control	11		N03	006	Electric blanket control
controlled-exchange	10		N06	007	Reversibility: controlled-not, controlled-exchange
controlled-not	10		N06	007	Reversibility: controlled-not, controlled-exchange
coordinates	11c	1	N02	002	"Reality" and coordinates.
coprimes	i		E49	030	Coprimes and greatest common divisor.
copying state	12		N08	007	Copying state.

correlation	09c 1 N10 031	Correlation and co-ignorance.
correlation	09c 3 N23 002	Correlation.
cos	01 E08 012	Celtic knots and other fun with cos and sin.
cos	01 E14 016	Useful cos and sin.
cos	02 E02 009	values for cos, sin
cos	04 N04 002	cos + sqrt(-1)sin as rotation
cosine	01 N04 004	Cosine
cosine	iv E09 014	Cosine and sine.
cosmology	11c 2 N31 033	Cosmology.
counting	i E02 017	Counting in tongues.
creation	07c E41 045	Creation and Annihilation.
criticality	09c 4 E26 033	Self-Organized Criticality.
cross product	07c E31 020	Gibbs cross product
cross-products	11d 1 N06 013	Invariants, cross-products and convention.
crystal symmetries	08c 2 N24 016	Non-translational crystal symmetries.
crystals	08c 2 N20 003	1D crystals, gratings, CDs
crystals	08c 2 N21 006	2D crystals
cube root	v 2 N01 001	Cube root of 8.
cube roots	i N06 010	Square roots and cube roots
cubes	i E07 017	Cubes.
cubic	v 2 N04 003	Slope of cubic.
curl	11c 1 N06 013	Divergence and Curl.
curl	11c 1 N15 046	Gradient, divergence and curl with absolute slope.
current	11d 5 E14 037	Current from faze invariance.
curvature	11c 1 E37 090	Absolute slope and curvature.
curvature	11c 1 E46 100	Curvature of lines.
curvature	11c 1 N17 053	Curvature.
curvature tensor	11c 1 E40 092	Number of components of the curvature tensor.
curves	v 1 N09 010	Slopes of curves.
cycles	09c 2 E14 071	Cycles.
dark energy	11c 2 N32 037	Negative pressure and dark energy.
database search	11d 6 N44 019	Database search.
de moivre	04 E01 006	De Moivre
decision trees	09c 1 E64 083	Decision trees.
densities	09c 1 N03 005	Distributions and densities.
density matrices	11d 4 E07 049	Density matrices and inverse tensor product.
determinant	03 N07 005	unit determinant
determinant	08c 1 N08 005	Matrix invariant sets share eigenvalues, determinant, trace
determinants	03 N08 006	Digression on determinants.
deutsch	07b N07 005	Developments after Deutsch's seminal 1985 paper
diagonalizing	iv E22 024	Diagonalizing matrices.
diagonalizing	iv N10 009	Diagonalizing matrices.
diagrams	11d 5 N34 013	Diagrams and QED.
differences	i N03 005	Rules and differences
differential equations	09c 3 E30 056	Chemical kinetics and differential equations.
differential equations	09c 3 E30 062	Coupled linear first-order differential equations.
diffusivity	09c 3 N25 016	Mobility, diffusivity and Brownian motion.
digital signal process	09 E24 022	Digital signal processor, DSP filters.
dirac equation	08c 4 E41 052	Dirac equation
direct	08c 1 N09 006	Other representations: trivial, direct, permutation
direction cosines	07c E30 019	Direction cosines.
dispersion relations	11d 2 E07 026	Dispersion relations.
dissipation	09c 3 N26 019	Three potentials and dissipation.
distance	03 N01 001	time and distance
distribution	09c 1 E48 069	When is a distribution the product of its marginals?
distribution continuous	09c 1 E40 057	Continuous distributions.

distribution continuous	09c	1	E41	058	More on continuous distributions.
distribution continuous	09c	1	E42	059	Ignorance and continuous distributions.
distribution continuous	09c	1	E43	061	Continuous distributions by antislope
distributions	09c	1	N03	005	Distributions and densities.
distributions	09c	1	N04	007	Aggregates: the moments of distributions.
div grad	11d	1	N04	008	Divergence, gradient and div grad.
divergence	11c	1	N06	013	Divergence and Curl.
divergence	11c	1	N15	046	Gradient, divergence and curl with absolute slope.
divergence	11d	1	N04	008	Divergence, gradient and div grad.
divergence-free curvatu	11c	1	E39	091	Divergence-free curvature.
divide and conquer	09		N06	009	Divide and Conquer
division	i		E45	025	Slopes: division
division	i		N09	012	Division: slopes.
division	iii		N09	010	Polynomial division.
dodecahedra	08c	1	N18	025	Dodecahedra Icosahedra.
dominance	09c	2	E12	066	Dominance. (A kinetic theory of conflict, 2.)
dot product	07c		E01	014	Dot product.
dot product	08c	2	E13	023	Dot product.
double slit	05		N04	002	Probabilities for Young's double slit
double slit	05		N06	004	Trigonometry for double slit
doves and hawks	09c	2	E11	064	Doves and hawks. (A kinetic theory of conflict, 1.)
e.coli	11		N04	008	Biology: the lac operon of E.coli, gene expression, attract
eigenvalues	03		N05	004	modifying Galileo, eigenvalues
eigenvalues	03		N06	005	matrix from fixed directions, eigenvalues
eigenvalues	04		E12	010	eigenvalues of rotation
eigenvalues	07c		N03	003	Height, width as eigenvalues not coordinates
eigenvalues	08c	1	N08	005	Matrix invariant sets share eigenvalues, determinant, trace
einstein-podolsky-rosen	11d	6	N46	028	Nonlocality: Einstein-Podolsky-Rosen.
elastic collision	07a		N15	008	Elastic collision
elasticity	09c	3	E26	041	Elasticity and viscosity
elational	07c		E34	026	Tensor Calculator I. Relational representation.
electric blanket	11		N03	006	Electric blanket control
electricity	11d	1	N02	004	Gravity vs. Electricity.
electrodynamics	11d	1	N05	009	Electrodynamics departs from gravitation.
electromagnetic	11d	3	N13	001	The electromagnetic Schr\odinger equation.
electromagnetic waves	11d	1	N07	019	Electromagnetic waves.
electrons	05		N09	008	Two ways to collide electrons - new Feynman rule - bosons,
electrons	06		N02	001	Two polarization states of electrons
electroweak	11d	5	N35	016	Chirality and electroweak.
emergence	09c	2	E46	079	Emergence
emergence	09c	2	N22	061	Emergence.
encryption	i		E54	036	Secret codes and encryption.
energentum	07a		N09	005	Gives the transformation of energentum, $E^2 - c^2p^2 = m^2c^2$
energentum	07a		N10	005	Energentum is conserved.
energy	07a		N04	002	Energy, momentum and frequency, wavenumber - Planck's const
energy	08c	4	N36	017	Symmetry and Conservation: Energy
energy bands in crystal	07a		E16	013	Energy bands in crystals
energy scales	11d	1	N03	004	Energy scales and momentum scales.
entanglement	07b		N06	004	State space and entanglement
entanglement	11d	4	E08	049	Certainty and entanglement.
entropy	09c	2	N16	026	Entropy.
equations of state	09c	2	N20	044	Thermostatic equations of state.
ergosphere	11c	2	E09	049	The ergosphere.
errors correcting	11d	6	N45	024	Detecting errors and correcting errors.
errors detecting	11d	6	N45	024	Detecting errors and correcting errors.
euclid's algorithm	i		E50	030	Modular arithmetic and Euclid's algorithm.

euclid's algorithm	i	E51 031	Euclid's algorithm.
euclid's elements	10	E60 028	Euclid's Elements.
eugene	01	E07 011	Eugene's Clock
euler	i	E53 035	Fermat and Euler on modular powers.
euler angles	06	N03 002	Euler angles, transformation matrix
euler angles	06	N06 003	Special Euler angles
euler's formula	07c	E24 017	Euler's formula, edges, faces, vertices
euler's formula	12	E13 010	Euler's formula, edges, faces, vertices
expectation	09c 1	N07 021	Expectation, surprise and ignorance.
factor analysis	08	E10 017	Factor analysis/Principal components analysis in the measur
factorial	ii	E40 024	Factorial trees.
factorials	ii	N07 007	Factorials.
faze invariance	11d 5	E14 037	Current from faze invariance.
fermat	i	E53 035	Fermat and Euler on modular powers.
fermat	i	E56 039	Fermat's little theorem again.
fermions	05	N09 008	Two ways to collide electrons - new Feynman rule - bosons,
fermions	06	N14 007	Fermions and Bosons.
fermions	11d 4	N27 033	Fermions.
fermions	11d 5	N31 002	Fermions.
ferromagnets	09c 4	N34 018	Ferromagnets.
feynman	05	N03 002	Feynman's rules
feynman	11d 5	E25 038	Feynman's program Hamiltonian.
feynman rule	05	N09 008	Two ways to collide electrons - new Feynman rule - bosons,
fft	09	E14 014	FFT again.
fft	09	N05 007	The fast Fourier transform, FFT
field	11d 4	N24 024	A simple field.
fields	11c 1	N01 001	Fields and slopes.
fields	11c 1	N10 031	Fields in gypsum.
fission	07a	N14 007	Fission
fizzmezh	03	E20 013	The weird fizzmezh matrices.
flatness	11c 1	E42 096	Local flatness.
flipflop	11	N01 001	Memory: flipflop, feedback automata
fluctuations	09c 2	N15 021	Fluctuations, variations and samples.
forces	08c 4	E21 042	Forces and deformations.
forces	11d 3	N17 009	Other symmetries, other forces.
formal properties	04	N07 003	formal properties of numbers
fourier transf discrete	09	E23 022	Two-dimensional discrete Fourier transform
fourier transform	04	E14 011	Fourier transform inverse
fourier transform	09	E17 015	Modified inverse Fourier Transform.
fourier transform	09	E18 017	Fourier Transform with vector \$k, \ell\$.
fourier transform	09	E19 019	Continuous Fourier Transform.
fourier transform	09	N02 002	Fourier transform, FT
fourier transform	11d 6	N39 012	Binary Fourier transform.
fourier transform	11d 6	N40 013	Quantum Fourier transform.
fourier transform fast	09	N05 007	The fast Fourier transform, FFT
fractals	12	N03 002	Fractals
fractional	i	E46 027	Brocot fractional approximation
fractional dimension	12	E28 021	Fractional dimension
fractions	i	E48 029	Making fractions clear.
freqnum	07a	N08 004	The pre-timespace limit for freqnum.
frequency	07a	N04 002	Energy, momentum and frequency, wavenumber - Planck's const
fulladder	10	N05 005	Switching circuits: halfadder, fulladder
function	v 1	N06 006	Zeros of a function.
functionals	11d 5	N32 005	Functionals.
functions	02	N10 008	product of functions, sum of arguments
functions	09c 2	E32 076	Local inverses of functions.

functions	v	1	N05	004	Functions.
fusion	07a		N13	007	Fusion
galileo	03		N03	001	timespace, Galileo, Stan and Trav
galileo	03		N05	004	modifying Galileo, eigenvalues
galois	08c	1	E53	034	Symmetric field trip: Galois and the quintic
gas simulation	09c	2	N12	001	A gas simulation 1: the collisions
gas simulation	09c	2	N13	011	A gas simulation 2: statistics.
gauge theory	11d	3	E04	013	Gauge theory.
gauss elimination	08		N02	005	Gauss elimination
gauss' law	11c	1	E14	077	Gauss' law for volume integrals and surface integrals
gauss' law	11d	1	E04	022	Gauss' law for fields from charge.
gaussian integrals	11d	5	N33	008	Gaussian integrals.
gaussians	11d	5	E06	035	Matrix Gaussians.
gene expression	11		E30	019	gene expression, microarrays
gene expression	11		N04	008	Biology: the lac operon of E.coli, gene expression, attract
generators	v	1	E10	031	Rotation generators.
genetic	iii		N06	007	The Genetic Code.
genetic overlap	10		E37	020	Genetic overlap
geodesics	11c	1	N13	041	Parallel transport and geodesics.
geometric mean	09c	1	E14	044	Geometric mean and harmonic mean.
geometrical interpretat	09c	1	E46	068	Geometrical interpretations of constant sums.
geometry	11c	2	N34	043	Alternatives to geometry.
geometry	11d	3	N15	006	Links with geometry.
gibbs' paradox	09c	4	E22	029	Gibbs' paradox.
gini	v	2	E11	016	Gini and IGE.
golden ratio	ii		E15	019	Golden ratio.
goldstone	11d	3	E07	016	Goldstone and Higgs mechanisms.
gradient	11c	1	N15	046	Gradient, divergence and curl with absolute slope.
gradient	11d	1	N04	008	Divergence, gradient and div grad.
gratings	08c	2	N20	003	1D crystals, gratings, CDs
gravitation	11d	1	N05	009	Electrodynamics departs from gravitation.
gravitational	11c	2	N23	005	Gravitational redshift.
gravitational	11c	2	N33	039	Gravitational irreversibility.
gravitational waves	11c	2	E32	056	Gravitational waves.
gravity	11c	1	N07	018	Classical gravity.
gravity	11c	2	N24	009	Spherically symmetric gravity.
gravity	11c	2	N26	016	Rotationally symmetric gravity.
gravity	11c	2	N30	030	The source of gravity.
gravity	11d	1	N02	004	Gravity vs. Electricity.
greatest common divisor	i		E49	030	Coprimes and greatest common divisor.
green's functions	11d	5	N36	023	Green's functions.
greenhouse gases	08c	1	N14	017	Greenhouse gases: CO <sub>2</sub>
greenhouse gases	08c	1	N15	018	Greenhouse gases: H <sub>2</sub> O
group	08c	1	N04	003	Group properties
gypsum	11c	1	N10	031	Fields in gypsum.
gypsum coordinates	11c	1	N08	023	Gypsum coordinates.
H <sub>2</sub> O	08c	1	N15	018	Greenhouse gases: H <sub>2</sub> O
hadamard	07b		N03	001	Logic circuits and gates, not, Hadamard
half angles	06		N04	003	Half angles
half-	08c	3	E12	028	Half-Pauli matrices
halfadder	10		N05	005	Switching circuits: halfadder, fulladder
hamiltonian	08c	4	N39	030	The Hamiltonian and Schrödinger's Equation
hamiltonian	11d	2	E05	025	The Hamiltonian.
hamiltonian	11d	5	E25	038	Feynman's program Hamiltonian.
harmonic mean	09c	1	E14	044	Geometric mean and harmonic mean.
heat	09c	2	N22	052	Work and heat.

heat conduction	09c 3 E24 037	Viscosity and heat conduction.
hermite	iii E27 018	Hermite polynomials.
hermite polynomials	09c 1 E24 046	Legendre polynomials and Hermite polynomials.
hermitian transposes	11d 4 E31 054	Hermitian transposes of reflections, etc.
hexagonal numbers	12 E14 010	{\em Hexagonal numbers
hexahedra	08c 1 N17 024	Hexahedra Octahedra.
hierarchies	09c 2 E13 069	Hierarchies.
higgs	11d 3 E07 016	Goldstone and Higgs mechanisms.
histogram arithmetic	09c 1 N02 002	Histogram arithmetic.
histograms	09c 1 E07 042	Program to add histograms
histograms	09c 1 N01 001	Histograms.
hookean solid	09c 3 E26 044	Hookean solid.
hotplate geometry	11c 1 E36 087	Hotplate geometry.
huygens	11d 5 E22 038	Huygens 3D.
hyperboloid	11c 1 E51 106	Hyperboloid.
hypercube	i E09 018	Hypercube numbers.
hypercubes	i E24 020	Hypercubes: higher-dimensional squares.
hypercubes	ii E60 031	Hypercubes.
hyperdipyramids	i E25 021	Hyperdipyramids: higher-dimensional squares, part 2.
hyperspheres	01 E16 021	Hyperspheres.
hyperspheres	09c 1 E44 064	Hyperspheres.
icosahedra	08c 1 N18 025	Dodecahedra Icosahedra.
identity	iv N03 003	Identity matrix.
ige	v 2 E11 016	Gini and IGE.
ignorance	09c 1 E34 051	Increasing ignorance.
ignorance	09c 1 E42 059	Ignorance and continuous distributions.
ignorance	09c 1 N07 021	Expectation, surprise and ignorance.
ignorance	09c 1 N08 024	Does ignorance ever decrease?
ignorance	09c 1 N11 034	Conditional distributions and ignorance.
imagine that!	04 N06 002	sqrt(-1) as "imagine that!", 2-dimensional numbers
implication	10 N03 003	Implication operator
importance of a web pag	08 N01 001	Importance of a web page: cycles
importance of a web pag	08 N02 002	Importance of a web page: no cycles
index notation	11c 1 N03 005	Index notation and tensors.
individuality	09c 4 N35 020	Particle individuality and Bose-Einstein condensation.
induction	12 N04 003	Mathematical induction.
inelastic collisions	07a N11 006	Inelastic collisions
infinite groups	08c 2 N19 002	Infinite groups
infinite series	v 1 N15 020	Infinite series.
infinite series	v 1 N16 021	Programming the infinite series.
infinities	09c 4 E21 029	Infinities.
infinity	10 E11 013	More than one kind of infinity
inflation	11c 2 E25 052	Inflation.
inflection	09c 4 E07 027	Point of inflection.
inside knowledge	09c 1 N09 028	Inside knowledge: the clients of Joe and Sue revisited.
instantiation	12 N07 006	Instantiation.
integrals	09c 1 E22 045	Notation, integrals and antislopes
interest	ii N05 005	Interest.
interpreting numbers	04 E06 008	Interpreting numbers
interval	07a N06 003	Interval is invariant
interval algebra	07c N11 010	Interval algebra in 3D.
intervals	07c N10 010	Intervals plus locations.
intervals	i E52 032	How many intervals?
intervals	iv N06 006	Positions and intervals.
invariant	07a N06 003	Interval is invariant
invariant (normal) subg	08c 1 N07 005	Invariant (normal) subgroups



invariant sets	08c	1	N06	004	Invariant sets
invariant sets	08c	1	N08	005	Matrix invariant sets share eigenvalues, determinant, trace
invariants	11d	1	N06	013	Invariants, cross-products and convention.
inverse	04		E14	011	Fourier transform inverse
inverse	iv		N04	003	Matrix inverse.
inverses	v	1	E08	030	Inverses.
irreversibility	11c	2	N33	039	Gravitational irreversibility.
ising model	09c	4	E27	035	Ising model.
isospin	08c	4	N34	013	Isospin and quarks
iterate	08		N09	010	Iterate!
jpeg	09		N04	005	Joint Photographic Experts Group, JPEG
kepler i	08c	3	E38	034	Kepler I.
kepler ii	08c	3	E09	027	Kepler II.
kepler iii	08c	3	E36	031	Kepler III
kerr orbits	11c	2	N27	019	Kerr orbits and black holes.
key distribution	01		E20	024	Quantum key distribution.
key distribution	11d	6	N42	017	Quantum key distribution.
kinetic theory	09c	2	E11	064	Doves and hawks. (A kinetic theory of conflict, 1.)
kinetic theory	09c	2	E12	066	Dominance. (A kinetic theory of conflict, 2.)
kirchhoff circuits	09c	3	E19	029	Kirchhoff circuits.
kirchhoff lattices	09c	3	E21	031	Kirchhoff lattices: relations and operators.
l-systems	12		N06	004	L-systems
lac operon	11		N04	008	Biology: the lac operon of E.coli, gene expression, attract
language	11		N05	009	Language: parsing by finite automaton
laplace's equation	11d	2	N08	001	Partial Slope Equations: Laplace's Equation.
lattice dynamics	09c	3	E27	048	Lattice statics and lattice dynamics.
lattice statics	09c	3	E27	048	Lattice statics and lattice dynamics.
least squares	v	2	E11	018	Least squares fit.
least squares filter	09c	3	E05	027	Least squares filter.
legendre	iii		E27	018	Legendre polynomials.
legendre polynomials	09c	1	E24	046	Legendre polynomials and Hermite polynomials.
legendre transformation	08c	4	E37	050	Legendre transformation.
levi-civita symbol	11c	1	E23	081	Levi-Civita symbol, alternating tensors.
lie groups	08c	3	E16	028	Commutator algebra, Lie groups
light	02		N01	001	Operators: polarizing light
light	02		N02	002	Light beam as vector
light	05		N07	005	Light travels in straight lines
light	06		N01	001	Two polarization states of light
light	06		N10	005	Spin-1 and polarized light
light orbits	11c	2	N29	028	Light orbits.
lightspeed	06		N13	006	Lightspeed eliminates a third dimension
limits	v	1	N11	013	Limits.
linear equations	08		N04	004	Linear equations: Elementary row operations
linear operator	02		E16	011	linear operator
linear polarization	06		N11	005	Circular polarization to linear polarization
linear polarization	06		N12	006	Linear polarization rotates in two dimensions
local action	11d	3	N16	008	Local action versus action-at-a-distance.
local inverses	09c	2	E32	076	Local inverses of functions.
locations	07c		N10	010	Intervals plus locations.
logic	10		E52	021	Matrix logic.
logic	10		E55	026	Basic matrices for logic.
logic circuits and gate	07b		N03	001	Logic circuits and gates, not, Hadamard
logo programming	04		E03	007	Logo programming language
lorentz	03		E19	013	Lorentz ( $\neq$ ).
lorentz transformation	03		N09	007	Lorentz transformation
lorentz transformation	03		N10	009	Using the Lorentz transformation.

magnetic fields	11d	1	E09	022	Visualizing magnetic fields.
marginals	09c	1	E48	069	When is a distribution the product of its marginals?
marilyn vos savant	09c	1	E63	082	Marilyn vos Savant on the Monty Hall problem.
matrices	03		E20	013	The weird fizzle matrices.
matrices	04		E13	011	anticommuting matrices
matrices	04		N01	001	Matrices as numbers?
matrices	10		E55	026	Basic matrices for logic.
matrices	10		N07	010	Operators as matrices
matrices	11d	4	N19	008	Small matrices.
matrices	iv		E22	024	Diagonalizing matrices.
matrices	iv		N10	009	Diagonalizing matrices.
matrix	03		N06	005	matrix from fixed directions, eigenvalues
matrix	07c		E33	024	Tensor Calculator I. Matrix representation.
matrix	07c		E38	031	Matrix representations of Clifford "numbers".
matrix	08c	1	N08	005	Matrix invariant sets share eigenvalues, determinant, trace
matrix	10		E52	021	Matrix logic.
matrix	11d	5	E06	035	Matrix Gaussians.
matrix	iv		N01	001	Matrix multiplication.
matrix	iv		N04	003	Matrix inverse.
matrix mechanics	07c		E39	033	Matrix Mechanics.
matrix operations	07c		N13	013	Appendix: Summary of vector and matrix operations
matrix representation	08c	1	N10	007	Using traces to block-diagonalize a whole matrix representa
maximum speed	03		N04	003	maximum speed
maxwell distribution	09c	2	E19	074	Maxwell distribution.
maxwell distribution	09c	2	N14	016	The Boltzmann distribution and Maxwell distribution.
maxwell's equations	11d	3	E03	013	Maxwell's tensor and Maxwell's equations.
mean	09c	1	E13	043	Mean, median, mode.
measurement	11d	6	N38	008	Quantum Computing Measurement.
measuring	01		E03	010	Measuring angles.
median	09c	1	E13	043	Mean, median, mode.
memory	11		E37	022	Traffic memory.
memory	11		N01	001	Memory: flipflop, feedback automata
mensuration	v	1	E06	029	Mensuration
metric	11c	1	N09	029	The metric.
microarrays	11		E30	019	gene expression, microarrays
minimize	08		N11	012	Minimize subject to constraint
minimizing	v	2	E11	019	Minimizing.
mobility	09c	3	N25	016	Mobility, diffusivity and Brownian motion.
mode	09c	1	E13	043	Mean, median, mode.
modular arithmetic	i		E50	030	Modular arithmetic and Euclid's algorithm.
modular arithmetic	iii		E29	018	Modular arithmetic.
modular powers	i		E53	035	Fermat and Euler on modular powers.
modulo arithmetic	04		E18	011	Field trip: modulo arithmetic, solving by radicals
moir'e	08c	2	E38	028	Periodic interactions, vernier, moir'e
molecule	08c	1	N13	012	Triangle molecule
molecules	08c	1	N12	010	Molecules: 1D
molecules	08c	4	E20	040	Molecules
moments	09c	1	N04	007	Aggregates: the moments of distributions.
moments	11d	5	E09	036	Even moments.
momentum	07a		N04	002	Energy, momentum and frequency, wavenumber - Planck's const
momentum scales	11d	1	N03	004	Energy scales and momentum scales.
monatomic gases	09c	2	N19	039	State function for monatomic gases.
monotonic paths	ii		E34	023	Monotonic paths.
monty hall problem	09c	1	E63	082	Marilyn vos Savant on the Monty Hall problem.
multiplication	02		N05	003	Vector multiplication
multiplication	i		E41	025	Rectangular numbers> multiplication

multiplication	i	N08 012	Multiplication: rectangles.
multiplication	iv	N01 001	Matrix multiplication.
multiply	04	N09 003	Multiplying 2-numbers
multiply	iii	N08 009	Multiplying polynomials.
multivariate slopes	09c 2	N21 048	More on multivariate slopes.
mutual information	09c 1	E49 070	Mutual information from Chesapeake clams.
negative curvature	11c 1	N18 061	Negative curvature.
negative energy	11c 2	E28 053	Negative energy: warp drives.
negative mass	11c 2	E29 056	Negative mass.
negative numbers	i	N10 013	Negative numbers.
negative pressure	11c 2	N32 037	Negative pressure and dark energy.
newton's constant	11c 1	E13 077	Newton's constant.
newton's method	09c 1	E38 053	Newton's method 1.
newton's method	09c 1	E39 055	Newton's method 2.
newtonian limit	11c 2	E24 052	Newtonian limit.
newtonian liquid	09c 3	E26 046	Newtonian liquid.
noether's theorem	08c 4	N38 028	Symmetry and Conservation: Noether's Theorem
non-abelian	11d 3	E06 014	Abelian and non-Abelian symmetries.
nonlinear	i	N12 015	Nonlinear plots.
nonlocality	11d 6	N46 028	Nonlocality: Einstein-Podolsky-Rosen.
nonorthogonal axes	07c	E32 020	Nonorthogonal axes and tensor notation.
normal distribution	09c 1	N06 014	The normal distribution.
not	07b	N03 001	Logic circuits and gates, not, Hadamard
null spaces	08	E14 021	Null spaces and stoichiometry.
numbers 2-dimensional	04	N06 002	sqrt(-1) as "imagine that!", 2-dimensional numbers
numbers 2-dimensional	iv	E10 017	2-dimensional numbers
numbers 2-dimensional	04	E11 010	shear and 2-numbers
numbers 2-dimensional	04	N08 003	Adding 2-numbers
numbers 2-dimensional	04	N09 003	Multiplying 2-numbers
numbers 2-dimensional	05	N01 001	Amplitudes as 2-numbers
numerical solutions	11d 2	E04 024	Stability of numerical solutions of the wave equation.
octahedra	08c 1	N17 024	Hexahedra Octahedra.
ohm's law	09c 3	E25 041	"Ohm's law" for viscosity.
one-dimensional numbers	04	N02 001	One-dimensional numbers and 90-degree rotation
onsager relations	09c 3	N28 024	Combined transport. Onsager relations.
operator	10	N03 003	Implication operator
operators	09c 3	E21 031	Kirchhoff lattices: relations and operators.
operators	10	N04 004	Sixteen binary operators
operators	10	N07 010	Operators as matrices
oscillators	08c 4	E22 047	Spring oscillators.
ovations	09c 4	E23 030	Ovations.
overdetermined equation	08	N12 013	Overdetermined equations
overdetermined equation	08	N13 014	Overdetermined equations
parabolas	04	E07 008	Moving parabolas and their shadows
paraboloid	11c 1	E52 107	Paraboloid.
paradox	ii	E38 024	(Zeno's dichotomy paradox.)
parallel transport	11c 1	N13 041	Parallel transport and geodesics.
parent	12	N01 001	Recursion. Define "ancestor" in terms of "parent".
parentheses	11	N07 013	nested parentheses and pushdown automaton
parentheses	12	N02 001	Precedence without parentheses
parsing	11	N05 009	Language: parsing by finite automaton
partial slope equations	11d 2	N08 001	Partial Slope Equations: Laplace's Equation.
particle	07a	N02 001	Phase of particle $e^{-i\omega t}$
path integrals	11d 5	E03 034	Programming path integrals.
pauli	06	N05 003	Pauli matrices
pauli matrices	08c 3	E12 028	Half-Pauli matrices

peano curve	12	E07 009	Peano curve
percolation	09c 4	E06 027	Percolation.
perfect numbers	ii	E01 017	Perfect numbers
periodic boundary condi	08c 2	N22 012	Periodic boundary conditions
periodic interactions	08c 2	E38 028	Periodic interactions, vernier, moir\'e
periodic table	06	E15 010	The periodic table
periods	11d 6	N41 015	Finding periods.
permutation	08c 1	N03 002	Permutation notation
permutation	08c 1	N09 006	Other representations: trivial, direct, permutation
personality	08	E10 017	Factor analysis/Principal components analysis in the measur
perturbation approximat	11d 4	N26 031	Perturbation approximations.
phase	07a	N02 001	Phase of particle $e^{-i\omega t}$
phase	07a	N03 002	Phase is independent of observer
phase transitions	09c 4	E24 033	social phase transitions
phase transitions	09c 4	N29 002	Phase transitions.
phase transitions	09c 4	N30 003	Phase transitions in random graphs.
photons	05	N02 001	Photons
physics	09c 3	E31 075	Chemistry in the language of physics.
pictures	i	N11 013	Pictures of rules.
planck	07a	N04 002	Energy, momentum and frequency, wavenumber - Planck's const
platonic solids	07c	E20 017	Five Platonic solids
plots	i	N12 015	Nonlinear plots.
poetic symmetry	08c 2	E03 022	poetic symmetry
poetry	11	E40 023	concrete poetry
polar coordinates	11c 1	N11 035	Polar coordinates.
polar coordinates	11c 1	N16 049	Spherical polar coordinates.
polarization	06	N01 001	Two polarization states of light
polarization	06	N02 001	Two polarization states of electrons
polarized	06	N10 005	Spin-1 and polarized light
polarizing	01	N01 001	One polarizing filter
polarizing	01	N02 002	Two polarizing filters
polarizing	01	N05 005	A third polarizing filter
polarizing	01	N08 007	Two polarizing filters again
polarizing	02	N01 001	Operators: polarizing light
polarizing	02	N06 005	Polarizing filter as projection operator
polars	11c 1	E25 084	Orthonormal polars.
polynomial	iii	N09 010	Polynomial division.
polynomials	iii	E27 018	Hermite polynomials.
polynomials	iii	E27 018	Legendre polynomials.
polynomials	iii	N07 008	Polynomials.
polynomials	iii	N08 009	Multiplying polynomials.
polynomials	iii	N10 012	Bases and polynomials
positions	iv	N06 006	Positions and intervals.
potential energy	08c 4	E25 049	Potential energy
potentials	09c 3	N26 019	Three potentials and dissipation.
power laws	09c 4	E25 033	Power laws.
powers	ii	N01 001	Powers.
powers	ii	N04 004	Properties of powers.
powers	iii	N04 006	Bases and powers.
pre-timespace limit	07a	N08 004	The pre-timespace limit for freqnum.
precedence	12	N02 001	Precedence without parentheses
predicts	01	N06 005	Theory predicts
predicts	01	N07 007	Theory predicts wrong?
pressure	09c 2	N18 035	Pressure.
primes	i	N07 010	Primes.
principal axes	09c 3	E26 047	Principal axes.

principal components an	08	E10 017	Factor analysis/Principal components analysis in the measur
probabilities	05	N04 002	Probabilities for Young's double slit
probability	10	E34 019	Sets and probability
product	02	N10 008	product of functions, sum of arguments
product rule	08c 3	E22 029	Slope rules, product rule, chain rule
program	11d 5	E25 038	Feynman's program Hamiltonian.
programming	11d 5	E03 034	Programming path integrals.
programming	12	N05 004	Recursion. Programming languages.
programming	i	N04 005	Rules and programming.
programming	v 1	N16 021	Programming the infinite series.
projection	02	N06 005	Polarizing filter as projection operator
projection	iv	E21 023	Projection and reflection.
projections	02	N07 005	Three projections
propagators	11d 5	N37 030	Propagators.
protor calculator	11c 1	N05 011	The protor calculator 1.
protor calculator	11c 1	N20 067	More protor calculator.
protors	11c 1	N04 008	Protors.
pseudovectors	07c	N05 005	Twirl and area are " pseudovectors" or "axial vectors"
pythagoras	02	N09 007	two rotations, Pythagoras
pythagoras	v 2	E04 013	Pythagoras.
q-bits	06	N08 004	Two q-bits
qed	11d 5	N34 013	Diagrams and QED.
quadratic forms	08	E15 024	Quadratic forms and stability.
quantitative	01	E01 010	Quantitative thinking is important.
quantum	01	E20 024	Quantum key distribution.
quantum computer	11d 6	N47 029	Building a quantum computer.
quantum computers	07b	N08 005	Physical construction of quantum computers
quantum computing	11d 6	N38 003	Quantum Computing.
quantum computing	11d 6	N38 004	Quantum Computing Binary gates.
quantum computing	11d 6	N38 008	Quantum Computing Measurement.
quantum computing	11d 6	N38 012	Quantum Computing Ternary gates.
quantum distributions	09c 1	N05 011	Quantum distributions
quantum field theory	11d 4	N30 045	Relativistic quantum field theory redux, so far.
quantum fields	11d 4	N18 001	Introduction to Quantum Fields.
quantum physics	01	E19 022	Can quantum physics be made more complete?
quantum physics	11d 4	E09 050	Can quantum physics be made more complete? (Part II).
quarks	08c 4	N34 013	Isospin and quarks
quarks	11d 3	E08 020	Quarks and vacuum.
quintic	08c 1	E53 034	Symmetric field trip: Galois and the quintic
radians	v 1	E09 031	Radians.
random graphs	09c 4	N30 003	Phase transitions in random graphs.
rationals	iii	N05 006	Rationals $< 1$ .
realit	11c 1	N02 002	" Reality" and coordinates.
reasoning	i	N05 009	Reasoning with rules.
rectangles	i	N08 012	Multiplication: rectangles.
rectangular	i	E41 025	Rectangular numbers> multiplication
recursion	12	N01 001	Recursion. Define " ancestor" in terms of "parent".
recursion	12	N05 004	Recursion. Programming languages.
redshift	11c 2	N23 005	Gravitational redshift.
reflecting	08c 1	N05 003	Reflecting rotations, rotating reflections
reflection	07c	N08 008	Reflection
reflection	iv	E21 023	Projection and reflection.
reflections	08c 1	N02 002	Generating reflections
reflections	08c 1	N05 003	Reflecting rotations, rotating reflections
reflections	11d 4	E06 048	Sphere of reflections.
reflections	11d 4	E31 054	Hermitian transposes of reflections, etc.

reflections	iv	E17	021	Reflections, etc.
regular representation	08c	1	N11	008 Regular representation
relational composition	07c	E26	018	Relational composition
relations	09c	3	E21	031 Kirchhoff lattices: relations and operators.
relativistic quantum me	07a	N16	009	Equations of relativistic quantum mechanics
representations	08c	1	N09	006 Other representations: trivial, direct, permutation
representations	08c	3	N29	007 Representations of the spherical group.
resistance	09c	4	N31	009 Point-to-point resistance in a network.
resistors	09c	3	E20	030 Resistors in series and parallel.
reverse polish	11	N08	014	evaluation by reverse Polish: shunting
reversibility	10	N06	007	Reversibility: controlled-not, controlled-exchange
reversible heat engine	09c	2	N22	057 Carnot's reversible heat engine, second law of thermodynami
rich and poor	11	E35	021	rich and poor
root	v	2	N05	003 The root.
roots of unity	04	E09	010	Roots of unity.
rotates	06	N12	006	Linear polarization rotates in two dimensions
rotating	08c	1	N05	003 Reflecting rotations, rotating reflections
rotation	04	E12	010	eigenvalues of rotation
rotation	04	N04	002	cos + sqrt(-1)sin as rotation
rotation	07c	N07	007	Rotation
rotation	v	1	E10	031 Rotation generators.
rotation 90-degree	04	N02	001	One-dimensional numbers and 90-degree rotation
rotation 90-degree	04	N03	001	90-degree rotation as sqrt(-1)
rotation generators	v	1	E11	032 3D rotation generators.
rotations	02	N09	007	two rotations, Pythagoras
rotations	08c	1	N05	003 Reflecting rotations, rotating reflections
rotations	iv	N08	007	Rotations.
rotations	v	1	N18	024 Ninety-degree rotations.
rotations 3d	07c	N09	009	3D rotations
rsa	i	E55	038	Cracking RSA.
ruler	02	E17	012	ruler and compass
ruler and compass	04	E16	011	ruler and compass cannot trisect angles
rules	i	N01	001	Rules and sums.
rules	i	N03	005	Rules and differences
rules	i	N04	005	Rules and programming.
rules	i	N05	009	Reasoning with rules.
rules	i	N11	013	Pictures of rules.
sackur-tetrode equation	09c	2	E29	075 Sackur-Tetrode equation.
samples	09c	2	N15	021 Fluctuations, variations and samples.
sampling	09	E20	020	Artefacts of sampling.
schr\"odinger equation	11d	2	N10	010 The Schr\"odinger Equation I: Physics.
schr\"odinger equation	11d	2	N11	013 The Schr\"odinger Equation II: Animating in 1D.
schr\"odinger equation	11d	2	N12	019 The Schr\"odinger Equation III: Animating in 2D.
schr\"odinger equation	11d	3	N13	001 The electromagnetic Schr\"odinger equation.
schr\"odinger's equatio	08c	4	N39	030 The Hamiltonian and Schr\"odinger's Equation
schwarzschild metric	11c	2	E02	048 Schwarzschild metric.
schwarzschild orbits	11c	2	N25	011 Schwarzschild orbits and black holes.
second law of thermodyn	09c	2	N22	057 Carnot's reversible heat engine, second law of thermodynami
secret	i	E54	036	Secret codes and encryption.
self-organized	09c	4	E26	033 Self-Organized Criticality.
self-slope	v	1	N14	018 Self-slope.
series	12	E20	019	Series. Binomial coefficients.
sets	10	E34	019	Sets and probability
shear	04	E11	010	shear and 2-numbers
shear	iv	N09	008	Shear.
shunting	11	N08	014	evaluation by reverse Polish: shunting

sieve of eratosthenes	i	E40 024	Sieve of Eratosthenes
simplex	i	E08 017	Simplex numbers.
simplex	i	E23 020	Simplexes> higher-dimensional triangles.
simplex	iv	E24 028	Simplex arrays.
simplex coordinates	09c 1	E47 069	Simplex coordinates.
sin	01	E08 012	Celtic knots and other fun with cos and sin.
sin	01	E14 016	Useful cos and sin.
sin	02	E02 009	values for cos, sin
sin	04	N04 002	cos + sqrt(-1)sin as rotation
sine	iv	E09 014	Cosine and sine.
sketchpad	08	N07 007	Sketchpad example 1 (linear constraint)
sketchpad	08	N08 008	Sketchpad example 2 (nonlinear constraint)
sketchpad example	08	N10 011	Underdetermined equations: Sketchpad example 3 (point colli
slope	v 1	N20 027	Slope of $\$c\$$ and $\$s\$$ .
slope	v 2	N02 002	Slope.
slope	v 2	N04 003	Slope of cubic.
slope absolute	11c 1	E37 090	Absolute slope and curvature.
slope absolute	11c 1	N15 046	Gradient, divergence and curl with absolute slope.
slope equations	v 1	N17 023	Slope equations.
slope equations	v 1	N21 028	Connecting with slope equations.
slope rules	08c 3	E22 029	Slope rules, product rule, chain rule
slope rules	08c 3	N30 013	Spherical harmonics, slope rules
slopes	08	E28 027	Slopes of cos and sin.
slopes	11c 1	E01 075	Slopes commute?
slopes	11c 1	N01 001	Fields and slopes.
slopes	11d 4	E33 055	Slopes of Clifford functions.
slopes	11d 4	N28 035	Slopes and antislopes of 2D numbers, etc.
slopes	i	E45 025	Slopes: division
slopes	i	N09 012	Division: slopes.
slopes	v 1	N08 007	Slopes.
slopes	v 1	N09 010	Slopes of curves.
slopes absolute	11c 1	N14 043	Absolute slopes.
small numbers	ii	N09 014	Really small numbers.
solving by radicals	04	E18 011	Field trip: modulo arithmetic, solving by radicals
source vector	08	N03 003	Add equal columns of small numbers as source vector
special relativity	03	N11 010	Physical principles behind special relativity.
speed	03	N02 001	speed
spherical group	08c 3	N29 007	Representations of the spherical group.
spherical harmonics	08c 3	N30 013	Spherical harmonics, slope rules
spherical symmetry	08c 3	N27 004	Spherical symmetry.
spin	07c	E40 038	Spin and Clifford Algebra.
spin	11d 4	N21 014	Spin.
spin 2	06	E12 010	Spin 2.
spin 3/2	06	E11 008	Spin 3/2.
spin statistics	07a	E11 012	Spin statistics, etc.
spin-1	06	N10 005	Spin-1 and polarized light
spinors	11d 4	N22 018	Vectors and spinors.
spring constants	08c 1	E37 031	Spring constants.
square roots	i	N06 010	Square roots and cube roots
square roots	v 1	N13 016	Square roots.
square roots	v 2	N06 004	Square roots.
squares	i	E06 017	Squares.
squares	i	E24 020	Hypercubes: higher-dimensional squares.
squares	i	E25 021	Hyperdipyramids: higher-dimensional squares, part 2.
stability	08	E15 024	Quadratic forms and stability.
stability	11d 2	E04 024	Stability of numerical solutions of the wave equation.

stars	01	E15 017	Trigonometry can help us locate the stars.
state function	09c 2	N19 039	State function for monatomic gases.
state space	07b	N06 004	State space and entanglement
states	06	N01 001	States.
states	06	N01 001	Two polarization states of light
states	06	N02 001	Two polarization states of electrons
stationary action	08c 4	N37 020	Principle of Stationary Action.
statistics	09c 2	N13 011	A gas simulation 2: statistics.
stoichiometry	08	E14 021	Null spaces and stoichiometry.
straight lines	05	N07 005	Light travels in straight lines
su(2)	08c 4	N32 002	SU(2) formal and informal.
su(3)	08c 4	N33 006	SU(3).
sublimation	09c 4	N33 016	Sublimation.
sum	02	N10 008	product of functions, sum of arguments
sums	i	N01 001	Rules and sums.
surface integrals	11c 1	E14 077	Gauss' law for volume integrals and surface integrals
surprise	09c 1	N07 021	Expectation, surprise and ignorance.
surveying	08	E38 032	Surveying
swap gate	11d 6	E07 033	Implement swap gate.
switch-light	07b	N04 003	Classical circuit for switch-light
switch-light	07b	N05 003	Quantum circuit for switch-light
switch-light question	07b	N02 001	Switch-light question needs 1 function call
switching circuits	10	N05 005	Switching circuits: halfadder, fulladder
symbol system	09c 1	E62 081	Order of a symbol system.
symmetric polynomials	04	E22 014	'Symmetric polynomials'.
symmetric states	06	N09 004	Symmetric states and antisymmetric states
symmetries	11d 3	E06 014	Abelian and non-Abelian symmetries.
symmetries	11d 3	N17 009	Other symmetries, other forces.
symmetry	v 1	N04 004	Symmetry.
symmetry	v 1	N07 006	Symmetry, again.
symmetry and conservati	08c 4	N35 016	Symmetry and Conservation: Complementary Quantities
symmetry and conservati	08c 4	N36 017	Symmetry and Conservation: Energy
symmetry and conservati	08c 4	N38 028	Symmetry and Conservation: Noether's Theorem
tachyons	09	E25 033	Tachyons faster than light
temperature	09c 2	N17 029	Temperature.
tensor	07c	E32 020	Nonorthogonal axes and tensor notation.
tensor	07c	N04 004	Is twirl a tensor?
tensor	11c 1	N19 065	The Ricci tensor.
tensor	11d 3	E03 013	Maxwell's tensor and Maxwell's equations.
tensor calculator	07c	E33 024	Tensor Calculator I. Matrix representation.
tensor calculator	07c	E34 026	Tensor Calculator I. Relational representation.
tensor curvature	11c 1	E40 092	Number of components of the curvature tensor.
tensor product	11d 4	E07 049	Density matrices and inverse tensor product.
tensor product	11d 4	E26 054	Tensor product transposes.
tensor products	11d 4	N20 011	Tensor products.
tensors	11c 1	E23 081	Levi-Civita symbol, alternating tensors.
tensors	11c 1	E24 083	Physical tensors.
tensors	11c 1	N03 005	Index notation and tensors.
ternary gates	11d 6	N38 012	Quantum Computing Ternary gates.
tetrahedron	07c	E16 015	Tetrahedron.
tetrahedron	08c 1	N16 019	Tetrahedron.
theories	01	N11 009	Algorithm for scientific theories.
theory	01	N03 003	Theory
theory	01	N06 005	Theory predicts
theory	01	N07 007	Theory predicts wrong?
theory	01	N09 008	Testing theory



theory	01	N10 008	Theory fixed
thermostat	11	N02 005	Control: thermostat
thermostatic	09c 2	N20 044	Thermostatic equations of state.
thongs	09c 1	E61 080	Thongs.
three-dimensional rotat	iv	E11 017	Three-dimensional rotations.
through the earth	11c 1	E15 077	Message through the Earth.
throwing balls	v 2	E01 011	Throwing balls
tides	11c 2	N28 026	Tides.
time	03	N01 001	time and distance
time dilation	03	E18 012	time dilation
timespace	03	N03 001	timespace, Galileo, Stan and Trav
timespace	11c 2	N22 002	Curved timespace.
timespace	iv	E16 019	Velocities in timespace.
tipping point	11	E29 019	tipping point
total turtle turning	04	N10 004	Turtle graphics. Total Turtle Turning
trace	08c 1	N08 005	Matrix invariant sets share eigenvalues, determinant, trace
traces	08c 1	N10 007	Using traces to block-diagonalize a whole matrix representa
traffic	11	E37 022	Traffic memory.
traffic lights	11c 1	E16 079	Falling traffic lights
transformation matrix	06	N03 002	Euler angles, transformation matrix
transforming	06	N07 004	Transforming amplitudes
transforming space	iv	N07 006	Transforming space.
treasure island	04	E05 007	Treasure Island
trees	ii	E40 024	Factorial trees.
trees	ii	E41 024	Choose trees.
trees	ii	E42 025	Ways trees.
trees	ii	N02 001	Trees
trees	ii	N03 003	Inverting trees.
triangle symmetry	08c 1	N01 001	Triangle symmetry
triangles	01	E06 011	(Trig. and triangles)
triangles	i	E23 020	Simplexes> higher-dimensional triangles.
trig.	01	E06 011	(Trig. and triangles)
trigonometry	01	E15 017	Trigonometry can help us locate the stars.
trigonometry	05	N06 004	Trigonometry for double slit
trisect	04	E16 011	ruler and compass cannot trisect angles
trivial	08c 1	N09 006	Other representations: trivial, direct, permutation
truth	i	E01 016	Mathematical truth
turing machine	11	E48 025	Turing machine
turtle graphics	04	N10 004	Turtle graphics. Total Turtle Turning
two-dimensional numbers	v 1	N19 026	Two-dimensional numbers.
uncertainty	11d 4	E02 046	Heisenberg uncertainty.
uncertainty	11d 4	E03 046	More uncertainty.
uncertainty principle	09	N07 010	The Uncertainty Principle
underdetermined equatio	08	N10 011	Underdetermined equations: Sketchpad example 3 (point colli
vacuum	11d 3	E08 020	Quarks and vacuum.
van der waals	09c 4	N32 012	Van der Waals.
variations	09c 2	N15 021	Fluctuations, variations and samples.
vector	02	N02 002	Light beam as vector
vector	02	N05 003	Vector multiplication
vector	04	N05 002	$x + \sqrt{-1}y$ as vector
vector	07c	N13 013	Appendix: Summary of vector and matrix operations
vector	09	E18 017	Fourier Transform with vector $\mathbf{k}$ , $\mathbf{ell}$ .
vector space	09	N01 001	2D numbers give 5D vector space
vectors	07c	N01 001	Vectors are real.
vectors	07c	N02 002	Some pairs are not vectors
vectors	07c	N06 006	Vectors and Areas and .. All Together

vectors	11d 4 N22 018	Vectors and spinors.
vectors	iv N02 002	Vectors.
vectors	iv N05 004	Vectors in space.
velocities	iv E16 019	Velocities in timespace.
vernier	08c 2 E38 028	Periodic interactions, vernier, moir\'e
viscosity	09c 3 E24 037	Viscosity and heat conduction.
viscosity	09c 3 E25 041	‘‘ Ohm’s law’’ for viscosity.
viscosity	09c 3 E26 041	Elasticity and viscosity
visualizations	i N02 003	Some visualizations.
visualizing	07a E02 010	Visualizing waves
visualizing	11d 1 E09 022	Visualizing magnetic fields.
volume integrals	11c 1 E14 077	Gauss’ law for volume integrals and surface integrals
volumes	v 2 N09 008	Volumes.
wallpaper groups	08c 2 E23 026	Wallpaper groups.
wallpaper groups	08c 2 N25 016	Wallpaper groups.
warp drives	11c 2 E28 053	Negative energy: warp drives.
wave equation	11d 2 E04 024	Stability of numerical solutions of the wave equation.
wave equation	11d 2 N09 007	The Wave Equation.
wavelength	05 N05 003	Wavelength
wavenumber	07a N04 002	Energy, momentum and frequency, wavenumber - Planck’s const
wavepacket	11d 3 N14 003	Simulating a charged wavepacket moving near a current.
waves	07a E01 010	Waves
waves	07a E02 010	Visualizing waves
waves	08c 2 N22 011	2D waves
ways	ii E42 025	Ways trees.
work	09c 2 N22 052	Work and heat.
$x^2 - x - 1 = 0$	v 1 N01 001	Solving $x^2 - x - 1 = 0$
$x^2 - x - 1 = 0$	v 1 N02 001	Picture of $x^2 - x - 1 = 0$
xor	10 E53 024	{\bf xor} and {\bf and}.
yukawa potential	11d 4 N25 028	The Yukawa potential.
z-order	iii E14 015	Z-order
zeno	ii E38 024	(Zeno’s dichotomy paradox.)
zeros	v 1 N06 006	Zeros of a function.
zeros	v 1 N12 015	Back to the zeros of $\frac{5}{2}x^2 - \frac{1}{2}x - 2$ .