

Kent Academic Repository

Full text document (pdf)

Citation for published version

Hopkins, Tim and Morse, David R. (1992) Cumulative Index to the ACM Algorithms. Technical report. , University of Kent, Canterbury, UK

DOI

Link to record in KAR

<http://kar.kent.ac.uk/21026/>

Document Version

UNSPECIFIED

Copyright & reuse

Content in the Kent Academic Repository is made available for research purposes. Unless otherwise stated all content is protected by copyright and in the absence of an open licence (eg Creative Commons), permissions for further reuse of content should be sought from the publisher, author or other copyright holder.

Versions of research

The version in the Kent Academic Repository may differ from the final published version.

Users are advised to check <http://kar.kent.ac.uk> for the status of the paper. **Users should always cite the published version of record.**

Enquiries

For any further enquiries regarding the licence status of this document, please contact:

researchsupport@kent.ac.uk

If you believe this document infringes copyright then please contact the KAR admin team with the take-down information provided at <http://kar.kent.ac.uk/contact.html>

Cumulative Index to the ACM Algorithms

Tim Hopkins and David Morse
Computing Laboratory
University of Kent
Canterbury
Kent, CT2 7NF, UK

October 6, 1992

Abstract

This report contains a cumulative index to the *Collected Algorithms of the ACM*. The algorithms are classified using the modified SHARE classification, several different views of which are provided in Chapter 1. The source codes of these routines originally appeared in the *Communications of the ACM* and, from Algorithm 493, in the *ACM Transactions on Mathematical Software*. All algorithms up to and including those appearing in the December 1991 issue of TOMS are included in the index. Information on how to obtain sources of the algorithms is given in Appendix A.

The references given in the index provide the original source in bold face followed by any published remarks or certificates. The format of each reference is

<journal> <volume>:<page>

where <journal> is C for CACM, T for TOMS and, in the single case of Algorithm 568, X for *Transactions on Programming Languages and Systems*.

The index was built from a bibliographic database which is an extension to that previously provided as Algorithm 620. This extended database plus a set of Fortran 77 routines to manipulate individual items has been published as [1]. The complete submitted remark is included in this report as Appendix B.

We have also added a perl script for performing a number of transformations of the original database. This is faster and more easily modified than the original Fortran routines. It is described in more detail in Appendix A.

We hope that users of numerical software will find this index a good starting point in their search for reliable public domain numerical routines.

Contents

1	The SHARE Classification	2
2	Cumulative Index: Algorithms 1 – 701	8
A	Availability of Data, Tools and Algorithm Sources	33
B	A Remark on ACM TOMS Algorithm 620	35

Chapter 1

The SHARE Classification

A1	Real Arithmetic, Number Theory
A2	Complex Arithmetic
B1	Trig and Inverse Trig Functions
B2	Hyperbolic Functions
B3	Exponential and Logarithmic Functions
B4	Roots and Powers
C1	Operations on Polynomials and Power Series
C2	Zeros of Polynomials
C5	Zeros of one or more Nonlinear Equations
C6	Summation of Series, Convergence Acceleration
D1	Quadrature
D2	Ordinary Differential Equations
D3	Partial Differential Equations
D4	Differentiation
D5	Integral Equations
E1	Interpolation
E2	Curve and Surface Fitting
E3	Smoothing
E4	Minimizing or Maximizing a Function
F1	Matrix Operations, including Inversion
F2	Eigenvalues and Eigenvectors of a Matrix
F3	Determinants
F4	Simultaneous Linear Equations
F5	Orthogonalization
G1	Simple Calculations on Statistical Data
G2	Correlation and Regression Analysis
G5	Random Number Generators
G6	Permutations and Combinations
G7	Subset Generators
H	Operations Research, Graph Structure
I5	Input – Composite
J6	Plotting
K2	Relocation
L2	Compiling
M1	Sorting
M2	Data Conversion and Scaling
O2	Simulation of Computing Structure
R2	Symbol Manipulation
S	Approximation of Special Functions
Y1	Physics Applications
Z	All Others

Figure 1.1: Classification by SHARE index

Z All Others
 S Approximation of Special Functions
 G6 Combinations and Permutations
 L2 Compiling
 A2 Complex Arithmetic
 I5 Composite Input
 O2 Computing Structure Simulation
 C6 Convergence Acceleration
 M2 Conversion and Scaling of Data
 G2 Correlation and Regression Analysis
 E2 Curve and Surface Fitting
 M2 Data Conversion and Scaling
 F3 Determinants
 D2 Differential Equations, Ordinary
 D3 Differential Equations, Partial
 D4 Differentiation
 F2 Eigenvalues and Eigenvectors of a Matrix
 B3 Exponential and Logarithmic Functions
 E4 Function Minimizing or Maximizing
 H Graph Structure, Operations Research
 B2 Hyperbolic Functions
 I5 Input—Composite
 D5 Integral Equations
 E1 Interpolation
 F1 Inversion of a Matrix
 F4 Linear Equations, Simultaneous
 F1 Matrix Operations, including Inversion
 B3 Logarithmic Functions and Exponential
 F2 Matrix Eigenvalues and Eigenvectors
 F1 Matrix Operations, Including Inversion
 F3 Matrix, Determinant of
 E4 Maximizing a Function
 E4 Minimizing a Function
 C5 Nonlinear Equations, Zeros of
 A1 Number Theory

Figure 1.2: SHARE classification by subject

C1	Operations on Polynomials and Power Series
H	Operations Research, Graph Structure
D2	Ordinary Differential Equations
F5	Orthogonalization
D3	Partial Differential Equations
G6	Permutations and Combinations
Y1	Physics Applications
J6	Plotting
C1	Polynomials, Operations on
C2	Polynomials, Zeros of
C1	Power Series, Operations on
B4	Powers and Roots
D1	Quadrature
G5	Random Number Generators
A1	Real Arithmetic
G2	Regression and Correlation
K2	Relocation
B4	Roots and Powers
M2	Scaling and Conversion of Data
C6	Series, Summation and Convergence Acceleration of
G1	Simple Calculations on Statistical Data
O2	Simulation of Computing Structure
F4	Simultaneous Linear Equations
E3	Smoothing
M1	Sorting
S	Special Functions, Approximation of
G2	Statistical Data, Correlation and Regression Analysis of
G1	Statistical Data, Simple Calculations on
G7	Subset Generators
C6	Summation of Series
E2	Surface and Curve Fitting
R2	Symbol Manipulation
B1	Trig and Inverse Trig Functions
F5	Vectors, Orthogonalization of
C5	Zeros of one or more Nonlinear Equations
C2	Zeros of Polynomials

Figure 1.2: SHARE classification by subject (contd.)

S04 Bernoulli and Euler Numbers and Polynomials
 S18 Bessel Function, Modified
 S19 Bessel Functions of Complex Argument
 S18 Bessel Functions of Pure Imaginary Argument
 S17 Bessel Functions of Real Argument
 S20 Bessel and Related Functions, Miscellaneous
 S14 Beta Function and Incomplete Beta Function
 S03 Binomial Coefficients
 S07 Circular Functions, Miscellaneous
 S19 Complex Argument, Bessel Functions of
 S13 Cosine Integrals
 S23 Curve-Fitting
 S04 Derivatives and Differences of Zero
 S15 Derivatives
 S04 Differences and Derivatives of Zero
 S23 Differentiation, Numerical
 S21 Elliptic Integrals and Functions
 S15 Error Integral
 S04 Euler and Bernoulli Numbers and Polynomials
 S13 Exponential Integrals
 S14 Factorial Function
 S03 Factorials
 S22 Functions: Miscellaneous Higher Mathematical Functions
 S14 Gamma Function and Incomplete Gamma Function
 S15 Hermite Polynomials and Functions
 S15 Higher Integrals
 S22 Higher Mathematical Functions, Miscellaneous
 S18 Imaginary Argument, Bessel Functions of
 S14 Incomplete Beta and Gamma Functions
 S13 Integrals of Exponentials, Logarithms, Sines, Cosines, etc.
 S21 Integrals, Elliptic
 S15 Integrals: Higher Integrals and the Error Integral

Figure 1.3: Classification of Special Functions

S23 Integration, Numerical
 S23 Interpolation
 S04 Inverse Powers, Sums of
 S19 Kelvin Functions
 S16 Legendre Functions
 S13 Logarithmic Integrals
 S22 Miscellaneous Higher Mathematical Functions
 S18 Modified Bessel Functions
 S15 Moments
 S23 Numerical Differentiation and Integration
 S03 Partitions
 S14 Polygamma Function
 S15 Polynomials, Hermite
 S04 Powers and Inverse Powers, Sums of
 S14 Psi Function
 S13 Sine Integrals
 S07 Spherical Functions, Miscellaneous
 S04 Sums of Powers and of Inverse Powers
 S21 Theta Functions
 S07 Trigonometric Functions, Natural
 S04 Zero, Differences and Derivatives of

Figure 1.3: Classification of Special Functions (contd.)

Chapter 2

Cumulative Index: Algorithms 1 – 701

A1 : Real Arithmetic, Number Theory

7	Euclidian Algorithm	C3:240
35	SIEVE	C4:151 C5:209 C5:438 C10:570
61	Procedures For Range Arithmetic	C4:319
68	Augmentation	C4:339 C4:498
72	Composition Generator	C4:498 C5:439
93	General Order Arithmetic	C5:344 C5:514
95	Generation of Partitions in Part-Count Form	C5:344
99	Evaluation of Jacobi Symbol	C5:345 C5:557
114	Generation of Partitions with Constraints	C5:434
139	Solutions of the Diophantine Equation	C5:556 C8:170
223	Prime Twins	C7:243
237	Greatest Common Divisor	C7:481 C7:702
262	Number of Restricted Partitions of N	C8:493
263	Partition Generator	C8:493
263A	Gomory 1	C8:601 C13:326
307	Symmetric Group Characters	C10:451 C11:14
310	Prime Number Generator 1	C10:569 C10:570 C13:192
311	Prime Number Generator 2	C10:570 C10:570
313	Multi-Dimensional Partition Generator	C10:666
356	A Prime Number Generator Using the Treesort Principle	C12:563
357	An Efficient Prime Number Generator	C12:563 C16:489
371	Partitions in Natural Order	C13:52
372	An Algorithm to Produce Complex Primes CSIEVE	C13:52 C13:695
373	Number of Doubly Restricted Partitions	C13:120
374	Restricted Partition Generator	C13:120
386	Greatest Common Divisor of n Integers and Multipliers	C13:447 C16:257
401	An Improved Algorithm to Produce Complex Primes	C13:693 C13:695
403	Circular Integer Partitioning	C14:48
448	Number of Multiply-Restricted Partitions	C16:379
469	Arithmetic Over a Finite Field	C16:699
524	MP: A Fortran Multiple-Precision Arithmetic Package	T4:71 T5:518
567	Extended Range Arithmetic and Normalized Legendre Polynomials	T7:141
665	MACHAR: A Subroutine to Dynamically Determine Machine Parameters	T14:303
693	A Fortran Package for Floating-point Multiple-precision Arithmetic	T17:273

A2 : Complex Arithmetic

116	Complex Division	C5:435
186	Complex Arithmetic	C6:386

312 Absolute Value and Square Root of a Complex Number **C10:665**

B1 : Trig and Inverse Trig Functions

206 Arccossin **C6:519** C8:104
229 Elementary Functions by Continued Fractions **C7:296** C12:692
241 Arctangent **C7:546**

B3 : Exponential and Logarithmic Functions

46 Exponential of a Complex Number **C4:178** C5:347
48 Logarithm of a Complex Number **C4:179** C5:347 C5:391
C7:485
243 Logarithm of a Complex Number **C7:660** C8:279

B4 : Roots and Powers

53 N th Roots of a Complex Number **C4:180** C4:322
106 Complex Number to a Real Power **C5:388** C5:557
190 Complex Power **C6:388**
650 Efficient Square Root Implementation on the 68000 **T13:138**

C1 : Operations on Polynomials and Power Series

29 Polynomial Transformer **C3:604**
131 Coefficient Determination **C5:551**
134 Exponential of Series **C5:553** C6:390
158 Exponentiation of Series **C6:104** C6:390 C6:522
193 Reversion of Series **C6:388** C6:745
273 SERREV **C9:11**
305 Symmetric Polynomials **C10:450** C11:272
337 Calculation of a Polynomial and Its Derivative Values by Horner Scheme **C11:633** C12:39
446 Ten Subroutines for the Manipulation of Chebyshev Series **C16:254** C18:276
604 A Fortran Program for the Calculation of an Extremal Polynomial **T9:381**
641 Exact Solution of General Systems of Linear Equations **T12:149**

C2 : Zeros of Polynomials

3 Solution of Polynomial Equation by Bairstow-Hitchcock Method **C3:74** C3:354 C4:105
C4:153 C4:181
30 Numerical Solution of the Polynomial Equation **C3:643** C4:238 C5:50
C10:293 T11:183
59 Zeros of a Real Polynomial by Resultant Procedure **C4:236**
75 Factors **C5:48** C5:392 C5:439

78	Rational Roots of Polynomials with Integer Coefficients	C5:97 C5:168 C5:440
105	Newton Maehly	C5:387 C6:389
174	A Posteriori Bounds on a Zero of a Polynomial	C6:311
256	Modified Graeffe Method	C8:379 C9:687
283	Simultaneous Displacement of Polynomial Roots if Real and Simple	C9:273
326	Roots of Low-Order Polynomial Equations	C11:269
340	Roots of Polynomials by a Root-Squaring and Resultant Routine	C11:779 C12:281
419	Zeros of a Complex Polynomial	C15:97 C17:157
429	Localization of the Roots of a Polynomial	C15:776 C16:490 C16:579
493	Zeros of a Real Polynomial	T1:178

C5 : Zeros of one or more Nonlinear Equations

2	Rootfinder	C3:74 C3:354 C3:475 C4:153
4	Bisection Routine	C3:174 C4:153
15	Rootfinder II	C3:475 C3:475 C3:602 C4:153
25	Real Zeros of An Arbitrary Function	C3:602 C4:153 C4:154
26	Rootfinder III	C3:603 C4:153
196	Muller's Method for Finding Roots of an Arbitrary Function	C6:442 C11:12
314	Finding a Solution of N Functional Equations in N Unknowns	C10:726 C12:38
316	Solution of Simultaneous Nonlinear Equations	C10:728 C14:493
365	Complex Root Finding	C12:686
378	Discretized Newton-like Method for Solving a System of Simultaneous Nonlinear Equations	C13:259
413	ENTCAF and ENTCRE: Evaluation of Normalized Taylor Coefficients of an Analytic Function	C14:669
443	Solution of the Transcendental Equation $w e^w = x$	C16:123 C17:225
502	Dependence of Solution of Nonlinear Systems on a Parameter	T2:98
554	BRENTM: A Fortran Subroutine for the Numerical Solution of Systems of Nonlinear Equations	T6:240
555	Chow-Yorke Algorithm for Fixed Points or Zeros of C^2 Maps	T6:252
566	Fortran Subroutines for Testing Unconstrained Optimization Software	T7:136
631	Finding a Bracketed Zero by Larkin's Method of Rational Interpolation	T11:120 T12:72
652	HOMPACK: A Suite of Codes for Globally Convergent Homotopy Algorithms	T13:281
666	CHABIS: A Mathematical Software Package for Locating and Evaluating Roots of Systems of Nonlinear Equations	T14:330
681	INTBIS, a Portable Interval Newton/Bisection Package	T16:152

C6 : Summation of Series, Convergence Acceleration

8	Euler Summation	C3:318 C6:663
128	Summation of Fourier Series	C5:513 C7:421
157	Fourier Series Approximation	C6:103 C6:521 C6:618
215	Shanks	C6:662 C7:297
255	Computation of Fourier Coefficients	C8:279 C12:636
277	Computation of Chebyshev Series Coefficients	C9:86
320	Harmonic Analysis for Symmetrically Distributed Data	C11:114
338	Algol Procedures For the Fast Fourier Transform	C11:773
339	An Algol Procedure for the Fast Fourier Transform with Arbitrary Factors	C11:776 C12:187
345	An Algol Convolution Procedure Based on the Fast Fourier Transform	C12:179 C12:566
393	Special Series Summation with Arbitrary Precision	C13:570 C15:468
473	Computation of Legendre Series Coefficients	C17:25
545	An Optimized Mass Storage FFT	T5:500
602	HURRY: An Acceleration Algorithm for Scalar Sequences and Series	T9:355

D1 : Quadrature

1	Quad I	C3:74
32	Multint	C4:106 C6:69 C11:826
60	Romberg Integration	C4:255 C5:168 C5:281 C7:420
84	Simpson's Integration	C5:208 C5:392 C5:440 C5:557
98	Evaluation of Definite Complex Line Integrals	C5:345
103	Simpson's Rule Integrator	C5:347
125	Weightcoeff	C5:510
145	Adaptive Numerical Integration by Simpson's Rule	C5:604 C6:167 C8:171
146	Multiple Integration	C5:604 C7:296
182	Nonrecursive Adaptive Integration	C6:315 C7:244
198	Adaptive Integration and Multiple Integration	C6:443
233	Simpson's Rule for Multiple Integration	C7:348 C13:512
257	Havie Integrator	C8:381 C9:795 C9:871
279	Chebyshev Quadrature	C9:270 C9:434 C10:294 C10:666
280	Abscissas and Weights for Gregory Quadrature	C9:271
281	Abscissas and Weights for Romberg Quadrature	C9:271 C10:188
303	An Adaptive Quadrature Procedure with Random Panel Sizes	C10:373
331	Gaussian Quadrature Formulas	C11:432 C12:280 C13:512
351	Modified Romberg Quadrature	C12:324 C13:263 C13:374 C13:449

353	Filon Quadrature	C12:457 C13:263
379	Squank (Simpson Quadrature Used Adaptively-Noise Killed)	C13:260 C15:1073
400	Modified Havie Integration	C13:622 C17:324
417	Rapid Computation of Weights of Interpolatory Quadrature Rules	C14:807
418	Calculation of Fourier Integrals	C15:47 C15:469 C17:324
424	Clenshaw-Curtis Quadrature	C15:353 C16:490 T5:240
427	Fourier Cosine Integral	C15:358
436	Product Type Trapezoidal Integration	C15:1070
437	Product Type Simpson's Integration	C15:1070
438	Product Type Two-point Gauss-Legendre-Simpson's Integration	C15:1071
439	Product Type Three-point Gauss-Legendre-Simpson's Integration	C15:1072
440	A Multidimensional Monte Carlo Quadrature with Adaptive Stratified Sampling	C16:49
453	Gaussian Quadrature Formulas for Bromwich's Integral	C16:486
468	Algorithm for Automatic Numerical Integration Over a Finite Interval	C16:694
584	CUBTRI – Automatic Cubature Over a Triangle	T8:210 T12:71
612	TRIEX: Integration Over a TRIangle Using Nonlinear EXtrapolation	T10:17
614	A Fortran Subroutine for Integration in H_p Spaces	T10:140
639	To Integrate Some Infinite Oscillating Tails	T12:24
647	Implementation and Relative Efficiency of Quasirandom Sequence Generators	T12:362
649	A Package for Computing Trigonometric Fourier Coefficients Based on Lyness's Algorithm	T13:97
655	IQPACK: Fortran Subroutines for the Weights of Interpolatory Quadratures	T13:399
672	Generation of Interpolatory Quadrature Rules of the Highest Degree of Precision with Preassigned Nodes for General Weight Functions	T15:137
691	Improving QUADPACK Automatic Integration Routines	T17:218
698	DCUHRE: An Adaptive Multidimensional Integration Routine for a Vector of Integrals	T17:452
699	A New Representation of Patterson's Quadrature Formulae	T17:457

D2 : Ordinary Differential Equations

9	Runge-Kutta Integration	C3:318 C9:273
194	ZERSOL	C6:441
218	Kutta Merson	C6:737 C7:585 C9:273
407	DIFSUB for Solution of Ordinary Differential Equations	C14:185 C16:448
461	Cubic Spline Solutions to a Class of Functional Differential Equations	C16:635
497	Automatic Integration of Functional Differential Equations	T1:369

504	GERK: Global Error Estimation for Ordinary Differential Equations	T2:200
534	STINT: STiff (differential equations) INTegrator	T4:399
569	COLSYS: Collocation Software for Boundary Value ODE's	T7:223 T12:283
596	A Program for a Locally Parametrized Continuation Process	T9:236
648	NSDTST and STDTST: Routines for Assessing the Performance of Initial Value Solvers	T13:28
658	ODESSA: An Ordinary Differential Equation Solver with Explicit Simultaneous Sensitivity Analysis	T14:61
669	BRK45: A Fortran Subroutine for Solving First-Order Systems of Nonstiff Initial Value Problems for Ordinary Differential Equations	T15:29 T17:424
670	A Runge-Kutta-Nyström Code	T15:31
687	A Decision Tree for the Numerical Solution of Initial Value Ordinary Differential Equations	T17:1
700	A Fortran Software Package for Sturm-Liouville Problems	T17:500 T17:481

D3 : Partial Differential Equations

392	Systems of Hyperbolic P.D.E.	C13:567 C15:1074
460	Calculation of Optimum Parameters for Alternating Direction Implicit Procedures	C16:633
494	PDEONE Solution of Systems of Partial Differential Equations	T1:261
527	A Fortran Implementation of the Generalized Marching Algorithm	T4:165
540	PDECOL: General Collocation Software for Partial Differential Equations	T5:326
541	Efficient Fortran Subprograms for the Solution of Separable Elliptic Partial Differential Equations	T5:352 T5:365
543	FFT9: Fast Solution of Helmholtz-Type Partial Differential Equations	T5:490
553	M3RK: An Explicit Time Integrator for Semidiscrete Parabolic Equations	T6:236
565	PDE TWO/PSETM/GEARB: Solution for Systems of Two-Dimensional Nonlinear Partial Differential Equations	T7:126
572	Solution of the Helmholtz Equation for the Dirichlet Problem on General Bounded Three Dimensional Regions	T7:239
593	A Package for the Helmholtz Equation in Nonrectangular Planar Regions	T9:117
621	Software with Low Storage Requirements for Two-Dimensional Nonlinear Parabolic Differential Equations	T10:378
637	GENCOL: Collocation on General Domains with Bicubic Hermite Polynomials	T11:413
638	INTCOL and HERMCOL: Collocation on Rectangular Domains with Bicubic Hermite Polynomials	T11:416
651	Algorithm HFFT: High-Order Fast-Direct Solution of Helmholtz Equation in Three Dimensions	T13:235
685	A Program for Solving Separable Elliptic Equations	T16:325

688	EPDCOL: A More Efficient PDECOL Code	T17:153
690	Chebyshev Polynomial Software for Elliptic-parabolic Systems of PDEs	T17:178

D4 : Differentiation

79	Difference Expression Coefficients	C5:97 C6:104
579	CPSC: Complex Power Series Coefficients	T7:542

D5 : Integral Equations

368	Numerical Inversion of Laplace Transforms	C13:47 C13:624
486	Numerical Inversion of Laplace Transform	C17:587 T2:395 T3:111 T10:354
503	An Automatic Program for Fredholm Integral Equations for the Second Kind	T2:196
619	Automatic Numerical Inversion of the Laplace Transform	T10:348
627	A Fortran Subroutine for Solving Volterra Integral Equations	T11:58
629	An Integral Equation Program for Laplace's Equation in Three Dimensions	T11:85
662	A FORTRAN Software Package for the Numerical Inversion of the Laplace Transform Based on Weeks' Method	T14:171 T16:405
682	Talbot's Method for the Laplace Inversion Problem	T16:158
689	Discretized Collocation and Iterated Collocation for Nonlinear Volterra Integral Equations of the Second Kind	T17:167

E1 : Interpolation

18	Rational Interpolation by Continued Fractions	C3:508 C5:437
70	Interpolation by Aitken	C4:497 C5:392
77	Interpolation Differentiation and Integration	C5:96 C5:348 C6:446 C6:663
167	Calculation of Confluent Divided Differences	C6:164 C6:523
168	Newton Interpolation with Backward Divided Differences	C6:165 C6:523
169	Newton Interpolation with Forward Divided Differences	C6:165 C6:523
187	Differences and Derivatives	C6:387
210	Lagrangian Interpolation	C6:616 C6:619
211	Hermite Interpolation	C6:617
264A	Interpolation in a Table	C8:602
416	Rapid Computation of Coefficients of Interpolation Formulas	C14:806
472	Procedures for Natural Spline Interpolation	C16:763
480	Procedures for Computing Smoothing and Interpolating Natural Splines	C17:463
507	Procedures for Quintic Natural Spline Interpolation	T2:281
526	Bivariate Interpolation and Smooth Surface Fitting for Irregularly Distributed Data Points	T4:160 T5:242

574	Shape-Preserving Osculatory Quadratic Splines	T7:384
585	A Subroutine for the General Interpolation and Extrapolation Problems	T8:290
623	Interpolation on the Surface of a Sphere	T10:437
624	Triangulation and Interpolation at Arbitrarily Distributed Points in the Plane	T10:440

E2 : Curve and Surface Fitting

28	Least Squares Fit by Orthogonal Polynomials	C3:604 C4:544 C10:293
37	Telescope 1	C4:151 C5:438 C6:445
38	Telescope 2	C4:151 C6:445
74	Curve Fitting with Constraints	C5:47 C6:316
91	Chebyshev Curve-Fit	C5:281 C6:167 C7:296 C10:803
164	Orthogonal Polynomial Least Squares Surface Fit	C6:162 C6:450
176	Least Squares Surface Fit	C6:313 C15:1073
177	Least Squares Solution with Constraints	C6:313 C6:390
275	Exponential Curve Fit	C9:85
276	Constrained Exponential Curve Fit	C9:85
295	Exponential Curve Fit	C10:87
296	Generalized Least Squares Fit by Orthogonal Polynomials	C10:87 C10:377 C12:636
318	Chebyshev Curve-Fit (Revised)	C10:801
375	Fitting Data to One Exponential	C13:120
376	Least Squares Fit by $f(x) = A \cos(Bx + C)$	C13:121
409	Discrete Chebychev Curve Fit	C14:355
414	Chebyshev Approximation of Continuous Functions by a Chebyshev System of Functions	C14:737
433	Interpolation and Smooth Curve Fitting Based on Local Procedures	C15:914 T2:208
458	Discrete Linear L_1 Approximation by Interval Linear Programming	C16:629
474	Bivariate Interpolation and Smooth Surface Fitting Based on Local Procedures	C17:26 T5:241
476	Six Subprograms for Curve Fitting Using Splines Under Tension	C17:220
485	Computation of g -Splines via a Factorization Method	C17:526
501	Fortran Translation of Algorithm 409 Discrete Chebyshev Curve Fit	T2:95 T4:95
510	Piecewise Linear Approximations to Tabulated Data	T2:388
514	A New Method of Cubic Curve Fitting Using Local Data	T3:175
525	ADAPT: Adaptive Smooth Curve Fitting	T4:82
592	A Fortran Subroutine for Computing the Optimal Estimate of $f(x)$	T9:98
600	Translation of Algorithm 507. Procedures for Quintic Natural Spline Interpolation	T9:258
634	CONSTR and EVAL: Routines for Fitting Multinomials in a Least-Squares Sense	T11:218

660	QSHEP2D: Quadratic Shepard Method for Bivariate Interpolation of Scattered Data	T14:149
661	QSHEP3D: Quadratic Shepard Method for Trivariate Interpolation of Scattered Data	T14:151
677	C^1 Surface Interpolation	T15:365
684	C^1 - and C^2 - Interpolation on Triangles with Quintic and Nonic Bivariate Polynomials	T16:253
697	Univariate Interpolation that has the Accuracy of a Third-degree Polynomial	T17:367

E3 : Smoothing

188	Smoothing 1.	C6:387
189	Smoothing 2.	C6:387
216	Smooth	C6:663
547	Fortran Routines For Discrete Cubic Spline Interpolation and Smoothing	T6:92

E4 : Minimizing or Maximizing a Function

129	Minifun	C5:550 C6:521
178	Direct Search	C6:313 C9:684 C11:498 C12:637 C12:638
203	STEEP1	C6:517 C7:585 C8:171
204	STEEP2	C6:519
205	ATIVE	C6:519 C8:171
251	Function Minimisation	C8:169 C9:686 C12:512 C14:358
315	The Damped Taylor's Series Method for Minimizing a Sum of Squares and for Solving Systems of Nonlinear Equations	C10:726 C12:513
387	Function Minimization and Linear Search	C13:509
450	Rosenbrock Function Minimization	C16:482 C17:470 C17:590 T2:300
454	The Complex Method for Constrained Optimization	C16:487 C17:471
500	Minimization of Unconstrained Multivariate Functions	T2:87 T3:112 T6:618
559	The Stationary Point of a Quadratic Function Subject to Linear Constraints	T6:432
573	NL2SOL – An Adaptive Nonlinear Least-Squares Algorithm	T7:369 T9:139
611	Subroutines for Unconstrained Minimization Using a Model/Trust-Region Approach	T9:503
617	DAFNE: A Differential-Equations Algorithm for Nonlinear Equations	T10:317
630	BBVSCG – A Variable-Storage Algorithm for Function Minimization	T11:103
667	SIGMA: A Stochastic-Integration Global Minimization Algorithm	T14:366

F1 : Matrix Operations, including Inversion

42	INVERT	C4:176 C4:498 C6:38 C6:445
50	Inverse of a Finite Segment of the Hilbert Matrix	C4:179 C5:50 C6:38
51	Adjust Inverse of a Matrix when an Element is Perturbed	C4:180 C5:391
52	A Set of Test Matrices	C4:180 C4:339 C4:498 C5:438 C6:39 C6:446
58	Matrix Inversion	C4:236 C5:347 C5:438 C5:438 C5:606
66	INVRS	C4:322 C5:50 C5:348
67	CRAM	C4:322 C5:348
120	Matrix Inversion II	C5:437 C6:40 C6:445
140	Matrix Inversion	C5:556 C6:448
150	SYMINV2	C6:67 C6:390 C6:390 C7:148
166	MonteCarlo	C6:164 C6:523
197	Matrix Division	C6:443 C7:148
230	Matrix Permutation	C7:347
231	Matrix Inversion	C7:347 C8:220
274	Generation of Hilbert Derived Test Matrix	C9:11 C12:407
287	Matrix Triangulation with Integer Arithmetic	C9:513
298	Determination of the Square Root of a Positive Definite Matrix	C10:182 C12:325
319	Triangular Factors of Modified Matrices	C11:12
325	Adjustment of the Inverse of a Symmetric Matrix When Two Symmetric Elements are Changed	C11:118
348	Matrix Scaling by Integer Programming	C12:212
358	Singular Value Decomposition of a Complex Matrix	C12:564
380	In-situ Transposition of a Rectangular Matrix	C13:324 C13:327 C15:49
467	Matrix Transposition in Place	C16:692 T5:520
508	Matrix Bandwidth and Profile Reduction	T2:375
509	A Hybrid Profile Reduction Algorithm	T2:378
513	Analysis of In-Situ Transposition	T3:104 T5:520
529	Permutations to Block Triangular Form	T4:189
539	Basic Linear Algebraic Subprogram for Fortran Usage	T5:324 T8:403 T9:140
575	Permutations for a Zero-Free Diagonal	T7:387
581	An Improved Algorithm for Computing the Singular Value Decomposition	T8:84
601	A sparse Matrix Package – Part II: Special Cases	T9:344
636	Fortran Subroutines for Estimating Sparse Hessian Matrices	T11:378
645	Subroutines for Testing Programs that Compute the Generalized Inverse of a Matrix	T12:274
653	Translation of Algorithm 539: PC-BLAS Basic Linear Algebra Subprograms for Fortran Usage with the INTEL8087 80287 Numeric Data Processor	T13:311

656	An Extended Set of Basic Linear Algebra Subprograms: Model Implementation and Test Programs	T14:18
663	Translation of Algorithm 539: Basic Linear Algebra Subprograms for Fortran Usage in Fortran 200 for the Cyber 205	T14:177
674	Fortran Codes for Estimating the One-Norm of a Real or Complex Matrix, with Applications to Condition Estimation	T14:381
679	A Set of Level 3 Basic Linear Algebra Subprograms	T16:18
692	Model Implementation and Test Package for the Sparse Basic Linear Algebra Subprograms	T17:264
694	A Collection of Test Matrices in MATLAB	T17:289
695	Software for a New Modified Cholesky Factorization	T17:306

F2 : Eigenvalues and Eigenvectors of a Matrix

85	Jacobi	C5:208 C5:440 C6:447
104	Reduction to Jacobi	C5:387
122	Tridiagonal Matrix	C5:482 C7:144
183	Reduction of a Symmetric Bandmatrix to Triple Diagonal Form	C6:315
253	Eigenvalues of a Real Symmetric Matrix by the QR Method	C8:217 C10:376
254	Eigenvalues and Eigenvectors of a Real Symmetric Matrix by the QR Method	C8:218 C10:376
270	Finding Eigenvalues by Gaussian Elimination	C8:668
297	Eigenvalues and Eigenvectors of the Symmetric System ($\mathbf{A} - \gamma\mathbf{B}$) $\mathbf{X} = 0$	C10:181
343	Eigenvalues and Eigenvectors of a Real Generator Matrix	C11:820 C13:122 C13:694 C15:466
384	Eigenvalues and Eigenvectors of a Real Symmetric Matrix	C13:369 C13:750
405	Roots of Matrix Pencils: The Generalized Eigenvalue Problem	C14:113 C15:1075
464	Eigenvalues of a Real Symmetric Tridiagonal Matrix	C16:689
496	The LZ Algorithm to Solve the Generalized Eigenvalue Problem for Complex Matrices	T1:271 T2:396
506	HQR3 and EXCHNG: Fortran Subroutines for Calculating and Ordering the Eigenvalues of a Real Upper Hessenberg Matrix	T2:275 T8:219
516	An Algorithm for Obtaining Confidence Intervals and Point Estimates Based on Ranks in the Two-Sample Location Problem	T3:183
517	A Program for Computing the Conditions Numbers of Matrix Eigenvalues Without Computer Eigenvector	T3:186
530	An Algorithm for Computing the Eigensystem of Skew-Symmetric Matrices and a Class of Symmetric Matrices	T4:286
535	The QZ Algorithm to Solve the Generalized Eigenvalue Problem for Complex Matrices	T4:404 T8:402 T10:476
538	Eigenvectors and Eigenvalues of Real Generalized Symmetric Matrices by Simultaneous Iteration	T5:118
560	JNF: An Algorithm for Numerical Computation of the Jordan Normal Form of a Complex Matrix	T6:437

570	LOPSI: A Simultaneous Iteration Algorithm for Real Matrices	T7:230
589	SICEDR: A Fortran Subroutine for Improving the Accuracy of Computed Matrix Eigenvalues	T8:371
590	DSUBSP AND EXCHQZ: Fortran Subroutines for Computing Deflating Subspaces With Specified Spectrum	T8:376 T10:207
598	An Algorithm to Compute Solvents of the Matrix Equation $\mathbf{AX}^2 + \mathbf{BX} + \mathbf{C} = 0$	T9:246
640	Efficient Calculation of Frequency Response Matrices from State Space Models	T12:26
646	PDFIND: A Routine to Find a Positive Definite Linear Combination of Two Real Symmetric Matrices	T12:278
696	An Inverse Rayleigh Iteration for Complex Band Matrices	T17:335

F3 : Determinants

41	Evaluation of Determinant	C4:176 C7:144 C6:520 C9:686
159	Determinant	C6:104 C6:739
170	Reduction of a Matrix Containing Polynomial Elements	C6:165 C6:450 C7:421
224	Evaluation of Determinant	C7:243 C7:702
269	Determinant Evaluation	C8:668 C9:686

F4 : Simultaneous Linear Equations

16	Crout with Pivoting	C3:507 C3:540 C4:154
17	TRDIAG	C3:508
24	Solution of Tri-Diagonal Linear Equations	C3:602
43	Crout with Pivoting II	C4:176 C4:182 C6:445
92	Simultaneous System of Equations and Matrix Inversion Routine	C5:286
107	Gauss's Method	C5:388 C6:39 C6:445
126	Gauss' Method	C5:511
135	Crout with Equilibration and Iteration	C5:553 C5:557 C7:421 C8:104
195	BANDSOLVE	C6:441 C15:1074
220	Gauss-Seidel	C6:739 C7:349
238	Conjugate Gradient Method	C7:481
288	Solution of Simultaneous Linear Diophantine Equations	C9:514
290	Linear Equations Exact Solutions	C9:683
328	Chebyshev Solution to An Overdetermined Linear System	C11:428 C12:326
406	Exact Solution of Linear Equations Using Residue Arithmetic	C14:180 C16:311
408	A Sparse Matrix Package (Part I)	C14:265 C16:311 C16:578 T3:303 T4:295 T6:456
423	Linear Equation Solver	C15:274
432	Solution of the Matrix Equation $\mathbf{Ax} + x\mathbf{B} = \mathbf{C}$	C15:820

470	Linear Systems with Almost Tridiagonal Matrix	C16:760
478	Solution of an Overdetermined System of Equations in the L_1 Norm	C17:319 C18:277
495	Solution of an Overdetermined System of Linear Equations in the Chebyshev Norm	T1:264
512	A Normalized Algorithm for the Solution of Positive Definite Symmetric Quindagonal Systems of Linear Equations	T3:96
522	ESOLVE: Congruence Techniques for the Exact Solution of Integer Systems of Linear Equations	T3:404
533	NSPIV: A Fortran Subroutine for Sparse Gaussian Elimination with Partial Pivoting	T4:391
544	L2A and L2B Weighted Least Squares Solutions by Modified Gram-Schmidt with Iterative Refinement	T5:494
546	SOLVEBLOK	T6:88
551	A Fortran Subroutine for the L_1 Solution of Overdetermined Systems of Linear Equations	T6:228
552	Solution of the Constrained L_1 Linear Approximation Problem	T6:231
563	A Program for Linearly Constrained Discrete L_1 Problems	T6:609
576	A Fortran Program for Solving $Ax = b$	T7:391
578	Solution of Real Linear Equations in a Paged Virtual Store	T7:537
582	The Gibbs-Poole-Stockmeyer and Gibbs-King Algorithms for Reordering Sparse Matrices	T8:190
586	ITPACK 2C: A Fortran Package for Solving Large Sparse Linear Systems by Adaptive Accelerated Iterative Methods	T8:302
587	Two Algorithms for the Linearly Constrained Least Squares Problem	T8:323
603	COLROW and ARCECO: Fortran Packages for Solving Almost Block Diagonal Linear Systems by Modified Alternate Row and Column Elimination	T9:376 T14:196
618	Fortran Subroutines for Estimating sparse Jacobian Matrices	T10:346
633	An Algorithm for Linear Dependency Analysis of Multivariate Data	T11:170
635	An Algorithm for the Solution of Systems of Complex Linear Equations in the L_∞ Norm with Constraints on the Unknowns	T11:242
664	A Gauss Algorithm to Solve Systems with Large Banded Matrices Using Random Access Disk Storage	T14:257
701	GOLIATH – A Software System for the Exact Analysis of Rectangular Rank-deficient Sparse Rational Linear Systems	T17:519

F5 : Orthogonalization

127	Ortho	C5:511 C13:122
580	QRUP: A Set of Fortran Routines for Updating QR Factorizations	T7:548 T8:405
686	Fortran Subroutines for Updating the QR Decomposition	T16:369

G1 : Simple Calculations on Statistical Data

208	Discrete Convolution	C6:615
212	Frequency Distribution	C6:617
289	Confidence Interval For a Ratio	C9:514
330	Factorial Analysis of Variance	C11:431
359	Factorial Analysis of Variance	C12:631 C13:449
451	Chi-Square Quantiles	C16:483 C18:116
616	Fast Computation of the Hodges-Lehman Location Estimator	T10:265

G2 : Correlation and Regression Analysis

39	Correlation Coefficients with Matrix Multiplication	C4:152
142	Triangular Regression	C5:603
366	Regression Using Certain Direct Product Matrices	C12:687
367	Analysis of Variance for Balanced Experiments	C12:688
434	Exact Probabilities for $R \times C$ Contingency Tables	C15:991 C17:326 C18:117 T2:108
583	LSQR: Sparse Linear Equations and Least-Square Problems	T8:195
591	A Comprehensive Matrix-Free Algorithm for Analysis of Variance	T8:383
615	The Best Subset of Parameters in Least Absolute Value Regression	T10:202
642	A Fast Procedure for Calculating Minimum Cross-Validation Cubic Smoothing Splines	T12:150
643	FEXACT: A Fortran Subroutine for Fisher's Exact Test on Unordered $r \times c$ Contingency Tables	T12:154
675	Fortran Subroutines for Computing the Square Root Covariance Filter and Square Root Information Filter in Dense or Hessenberg Forms	T15:243
676	ODRPACK: Software for Weighted Orthogonal Distance Regression	T15:348

G5 : Random Number Generators

121	Normdev	C5:482 C8:556
133	Random	C5:553 C5:606 C6:105 C6:167
200	Normal Random	C6:444 C8:556
247	Radical-Inverse Quasi-Random Point Sequence	C7:701
266	Pseudo-Random Numbers	C8:605 C9:687 C9:687 C15:1072
267	Random Normal Deviate	C8:606
294	Uniform Random	C10:40
334	Normal Random Deviates	C11:498 C12:281 T8:89
342	Generator of Random Numbers Satisfying the Poisson Distribution	C11:819
369	Generator of Random Numbers Satisfying the Poisson Distribution	C13:49

370	General Random Number Generator	C13:49 C15:467
381	Random Vectors Uniform In Solid Angle	C13:326 C15:468
425	Generation of Random Correlated Normal Variables	C15:355 C17:325
441	Random Deviates from the Dipole Distribution	C16:51
488	A Gaussian Pseudo-Random Number Generator	C17:704
599	Sampling From Gamma and Poisson Distributions	T9:255
659	Implementing Sobol's Quasirandom Sequence Generator	T14:88
668	H2PEC: Sampling from the Hypergeometric Distribution	T14:397
678	BTPEC: Sampling from the Binomial Distribution	T15:394

G6 : Permutations and Combinations

71	Permutation	C4:497 C5:209 C5:209 C5:439
86	Permute	C5:208 C5:440
87	Permutation Generator	C5:209 C5:440 C5:514 C10:452
94	Combination	C5:344 C5:557 C5:606
102	Permutation in Lexicographical Order	C5:346 C10:452
115	Perm	C5:434 C5:514 C5:606
130	Permute	C5:551 C10:452
152	NEXCOM	C6:68 C6:385
154	Combination in Lexicographical Order	C6:103 C6:449
155	Combination in Any Order	C6:103 C6:449
156	Algebra of Sets	C6:103 C6:450
160	Combinatorial of M Things Taken N at a Time	C6:161 C6:450 C6:618
161	Combinatorial of M Things Taken One at a Time, Two at a Time, Up to N at a Time	C6:161 C6:450 C6:619
202	Generation of Permutations in Lexicographical Order	C6:517 C8:556 C10:452
235	Random Permutation	C7:420 C8:445
242	Permutations of a Set With Repetitions	C7:585
250	Inverse Permutation	C8:104 C8:670
306	Permutations with Repetitions	C10:450
308	Generation of Permutations in Pseudolexicographic Order	C10:452 C12:638
317	Permutation	C10:729
323	Generation of Permutations in Lexicographic Order	C11:117 C12:512 C16:577
329	Distributed of Indistinguishable Objects Into Distinguishable Slots	C11:430 C12:187
361	Permanent Function of a Square Matrix I and II	C12:634 C13:376
362	Generation of Random Permutations	C12:634
382	Combinations of M Out of N Objects	C13:368 C13:376
383	Permutations of a Set with Repetitions	C13:368 C13:376
452	Enumerating Combinations of m Out of n Objects	C16:485
466	Four Combinatorial Algorithms	C16:690

515 Generation of a Vector from the Lexicographical Index **T3:180**

G7 : Subset Generators

81 Economising A Sequence 1 **C5:166**
82 Economising A Sequence 2 **C5:167**
477 Generator of Set-Partitions to Exactly R Subsets **C17:224**
482 Transitivity Sets **C17:470**

H : Operations Research, Graph Structure

27 Assignment **C3:603** C6:618 C6:739
40 Critical Path Scheduling **C4:152** C4:392 C5:513
C7:349
69 Chain Tracing **C4:392**
83 Optimal Classification of Objects **C5:167**
96 Ancestor **C5:344** C6:104
97 Shortest Path **C5:345**
119 Evaluation of a Pert Network **C5:436** C8:330
141 Path Matrix **C5:556**
153 GOMORY **C6:68** C6:449
217 Minimum Excess Cost Curve **C6:737** C11:573
219 Topological Ordering for Pert Networks **C6:738** T3:303
248 Netflow **C8:103** C11:633 C11:633
258 Transport **C8:381** C8:445 C10:453
264 Map of Partitions into Integers **C8:493**
285 The Mutual Primal-Dual Method **C9:326** C10:453
286 Examination Scheduling **C9:433** C9:795
293 Transportation Problem **C9:869** C10:453 C11:271
324 Maxflow **C11:117** C16:309
333 Minit Algorithm For Linear Programming **C11:437** C12:408 C14:50
C16:310 C16:310
336 Netflow **C11:631** C13:192
341 Solution of Linear Programs in 0-1 Variables by Implicit
Enumeration **C11:782** C12:692 C13:263
350 Simplex Method Procedure Employing LU Decomposition **C12:275**
354 Generator of Spanning Trees **C12:511**
360 Shortest-Path Forest with Topological Ordering **C12:632**
394 Decision Table Translation **C13:571** C15:1074
397 An Integer Programming Problem **C13:620** C15:469
399 Spanning Tree **C13:621**
411 Three Procedures for the Stable Marriage Problem **C14:491**
415 Algorithm for the Assignment Problem (Rectangular Matrices) **C14:805**

422	Minimal Spanning Tree	C15:273 C16:448
430	Immediate Predominators in a Directed Graph	C15:777
431	A Computer Routine for Quadratic and Linear Programming Problems	C15:818 C17:157 C17:590
447	Efficient Algorithms for Graph Manipulation	C16:372
449	Solution of Linear Programming Problems in 0-1 Variables	C16:445
456	Routing Problem	C16:572 C17:706
457	Finding All Cliques of an Undirected Graph	C16:575
459	The Elementary Circuits of a Graph	C16:632 C18:119
481	Arrow to Precedence Network Transformation	C17:467
491	Basic Cycle Generation	C18:275
492	Generation of All the Cycles of a Graph from a Set of Basic Cycles	C18:310
520	An Automatic Revised Simplex Method for Constrained Resource Network Scheduling	T3:295
548	Solution of the Assignment Problem	T6:104
557	PAGP A Partitioning Algorithm for (Linear) Goal Programming Problems	T6:429
558	A Program for the Multifacility Location Problem with Rectilinear Distance by the Minimum-cut Approach	T6:430
562	Shortest Path Lengths	T6:450 T9:260
595	An Enumerative Algorithm for Finding Hamiltonian Circuits in a Directed Graph	T9:131
608	Approximate Solution of the Quadratic Assignment Problem	T9:461
613	Minimum Spanning Tree for Moderate Integer Weights	T10:108
632	A Program for the 0 – 1 Multiple Knapsack Problem	T11:135

I5 : Input – Composite

239	Free Field Read	C7:481
249	Outreal N	C8:104
335	A Set of Basic Input-Output Procedures	C11:567

J6 : Plotting

162	XYMOVE Plotting	C6:161 C6:450 C7:482
278	Graph Plotter	C9:88
412	Graph Plotter	C14:492 C16:489
420	Hidden-Line Plotting Program	C15:100 C16:448 C16:578 C17:324 C17:324 C17:706
463	Algorithms SCALE1, SCALE2, and SCALE3 for Determination of Scales on Computer Generated Plots	C16:639
475	Visible Surface Plotting Program	C17:152 C18:202 C18:276 C18:277 T1:381 T2:109 T5:521

483	Masked Three-Dimensional Plot Program with Rotations	C17:520 T1:285
531	Contour Plotting	T4:290
625	A Two-Dimensional Domain processor	T10:453
626	TRICP: A Contour Plot Program for Triangular Meshes	T10:473
657	Software for Plotting Contour Surfaces of a Function of Three Variables	T14:42 T16:109
671	FARB-E-2D: Fill Area with Bicubics on Rectangles – A Contour Plot Program	T15:79

K2 : Relocation

173	ASSIGN	C6:311 C6:619 C6:619
284	Interchange of Two Blocks of Data	C9:326 T2:392
302	Transpose Vector Stored Array	C10:292 C12:326

L2 : Compiling

265	Find Precedence Functions	C8:604
-----	---------------------------	---------------

M1 : Sorting

23	Math Sort	C3:601 C4:238
63	Partition	C4:321 C5:439 C6:446
64	Quicksort	C4:321 C5:439 C6:446 C17:143
65	Find	C4:321 C5:439 C6:446
76	Sorting Procedures	C5:48 C5:348
113	Treesort	C5:434
143	Treesort 1	C5:604
144	Treesort 2	C5:604
151	Location of a Vector in a Lexicographically Ordered List	C6:68
175	Shuttle Sort	C6:312 C6:619 C6:739 C7:296
201	Shellsort	C6:445 C7:349 C13:373 C17:143
207	Stringsrt	C6:615 C7:585 C17:143
232	Heapsort	C7:347
245	Treesort 3	C7:701 C8:445 C13:371 C17:143
271	Quickersort	C8:669 C9:354 C17:143
347	An Efficient Algorithm for Sorting with Minimal Storage	C12:185 C13:54 C13:624 T2:290
402	Increasing the Efficiency of Quicksort	C13:693 C16:311 C17:143
410	Partial Sorting	C14:357
426	Merge Sort Algorithm	C15:357 C17:706 T2:290
489	The Algorithm SELECT – for Finding the i th Smallest of n Elements	C18:173 T2:301

M2 : Data Conversion and Scaling

673 Dynamic Huffman Coding **T15:158**

O2 : Simulation of Computing Structure

100 Add Item to Chain-Linked List **C5:346**
101 Remove Item From Chain-Linked List **C5:346**
137 Nesting of For Statement I **C5:555**
138 Nesting of For Statement II **C5:555**
268 Algol 60 Reference Language Editor **C8:667** C12:407

R2 : Symbol Manipulation

377 Symbolic Expansion of Algebraic Expressions **C13:191**
628 An Algorithm for Constructing Canonical Bases of Polynomial Ideals **T11:66**

S : Approximation of Special Functions

S03

19 Binomial Coefficients **C3:540** C5:347 C5:438
33 Factorial **C4:106**

S13

14 Complex Exponential Integral **C3:406**
20 Real Exponential Integral **C3:540** C4:105 C4:182
108 Definite Exponential Integrals A **C5:388** C5:393
109 Definite Exponential Integrals B **C5:388** C5:393
385 Exponential Integral $E_i(x)$ **C13:446** C13:448 C13:750
C15:1074
471 Exponential Integrals **C16:761**
556 Exponential Integrals **T6:420** T9:525
609 A Portable Fortran Subroutine for the Bickley Functions $Ki_n(x)$ **T9:480**
683 A Portable Fortran Subroutine for Exponential Integrals of a Complex Argument **T16:178**

S14

31 Gamma Function **C4:105** C5:605 C6:38
34 Gamma Function **C4:106** C5:391 C9:685
54 Gamma Function for Range 1 to 2 **C4:180** C9:685
80 Reciprocal Gamma Function of Real Argument **C5:166** C9:685
147 PSIF **C5:605** C6:168 C12:691

179	Incomplete Beta Ratio	C6:314 C10:375 C17:156 T2:207
221	Gamma Function	C7:143 C7:586 C9:685
222	Incomplete Beta Function Ratios	C7:143 C7:244
225	Gamma Function with Controlled Accuracy	C7:295 C7:586
291	Logarithm of Gamma Function	C9:684 C9:685 C11:14
309	Gamma Function with Arbitrary Precision	C10:511
321	<i>t</i> -Test Probabilities	C11:115 C13:124
322	<i>F</i> -Distribution	C11:116 C12:39 C14:117
344	Student's <i>t</i> -Distribution	C12:37 C13:124 C13:449
346	<i>F</i> -Test Probabilities	C12:184
349	Polygamma Functions with Arbitrary Precision	C12:213 T1:380
395	Student's <i>f</i> -Distribution	C13:617 T5:238 T7:247
396	Student's <i>f</i> -Quantiles	C13:619 T5:238 T7:250
404	Complex Gamma Function	C14:48 C16:489
421	Complex Gamma Function with Error Control	C15:271
435	Modified Incomplete Gamma Function	C15:993 T4:296
442	Normal Deviate	C16:51
465	Student's <i>t</i> Frequency	C16:690
487	Exact Cumulative Distribution of the Kolmogorov-Smirnov Statistic for Small Samples	C17:703 T2:111 T3:285
518	Incomplete Bessel Function I_0 : The von Mises Distribution	T3:279
519	Three Algorithms for Computing Kolmogorov-Smirnov Probabilities with Arbitrary Boundaries and Certification of Algorithm 487	T3:285
542	Incomplete Gamma Functions	T5:482
571	Statistics for von Mises' and Fisher's Distribution of Directions: $I_1(x)/I_0(x)$ $I_{1.5}(x)/I_{.5}(x)$	T7:233
610	A Portable Fortran Subroutine for the Derivation of the Psi Function	T9:494
654	Fortran Subroutines for Computing the Incomplete Gamma Function Ratios and their Inverse	T13:318

S15

11	Evaluation of the Hermite Polynomial $H_n(X)$ by Recursion	C3:353
123	Real Error Function $\text{erf}(x)$	C5:483 C6:316 C6:618 C7:145 C10:377
180	Error Function – Large x	C6:314 C10:377
181	Complimentary Error Function – Large x	C6:315 C7:702 C10:377
185	Normal Probability for Curve Fitting	C6:386
209	Gauss	C6:616 C7:148 C7:482 C10:377
226	Normal Distribution Function	C7:295 C10:377

272	Procedure for the Normal Distribution Functions	C8:789 C10:377 C11:498
299	Chi-Squared Integral	C10:243 C11:271 T2:393 T11:185
304	Normal Curve Integral	C10:374 C10:377 C11:271 C12:565 C13:624
363	Complex Error Function	C12:635 C15:465
462	Bivariate Normal Distribution	C16:638
521	Repeated Integrals of the Coerror Function	T3:301
680	Evaluation of the Complex Error Function	T16:47

S16

13	Evaluation of the Legendre Polynomial $P_n(X)$ by Recursion	C3:353 C4:105 C4:181
47	Associated Legendre Functions of the First Kind for Real or Imaginary Arguments	C4:178 C6:446 C12:635
62	A Set of Associate Legendre Polynomials of The Second Kind	C4:320 C4:544
259	Legendre Functions for Arguments Larger than One	C8:488 T3:204

S17

21	Bessel Function for a Set of Integer Orders	C3:600 C8:219
22	Riccati-Bessel Functions of First and Second Kind	C3:600 C13:448
44	Bessel Functions Computed Recursively	C4:177
49	Spherical Neumann Function	C4:179 T4:295
124	Hankel Function	C5:483 C8:790
163	Modified Hankel Function	C6:161 C6:522
236	Bessel Functions of the First Kind	C7:479 C8:105 T1:282
484	Evaluation of the Modified Bessel Functions $K_0(z)$ and $K_1(z)$ for Complex Arguments	C17:524
498	Airy Functions using Chebyshev Series Approximations	T1:372 T7:404
597	Sequence of Modified Bessel Functions of the First Kind	T9:242

S18

5	Bessel Function I Series Expansion	C3:240
6	Bessel Function I Asymptotic Expansion	C3:240
214	q -Bessel Functions $I_n(t)$	C6:662 C7:349
228	Q -Bessel Functions $\bar{I}_n(t)$	C7:295
511	CDC 6600 Subroutines IBESS and JBESS for Bessel Functions $I_\nu(x), J_\nu(x), \nu \geq 0, x \geq 0$	T3:93 T4:411

S19

57	Ber or Bei Function	C4:181 C5:392 C5:438
644	A Portable Package for Bessel Functions of a Complex Argument and Non-negative order	T12:265 T16:404

S20

88	Evaluation of Asymptotic Expression for the Fresnel Sine and Cosine Integrals	C5:280 C6:618
89	Evaluation of the Fresnel Sine Integral	C5:280 C6:618
90	Evaluation of the Fresnel Cosine Integral	C5:281 C6:618
213	Fresnel Integrals	C6:617 C7:661
244	Fresnel Integrals	C7:660
301	Airy Function	C10:291 C10:453
505	A List Insertion Sort for Keys with Arbitrary Key Distribution	T2:204

S21

55	Complete Elliptic Integral of The First Kind	C4:180 C6:166
56	Complete Elliptic Integral of The Second Kind	C4:180 C9:12
73	Incomplete Elliptic Integrals	C4:543 C4:544 C5:514 C6:69 C6:167
149	Complete Elliptic Integral	C5:605 C6:166 T4:95
165	Complete Elliptic Integrals	C6:163 C12:38
549	Weierstrass' Elliptic Functions	T6:112
577	Algorithms for Incomplete Elliptic Integrals	T7:398

S22

10	Evaluation of the Chebyshev Polynomial $T_n(X)$ by Recursion	C3:353 C4:181
12	Evaluation of the Laguerre Polynomial $L_n(X)$ by Recursion	C3:353
36	Tchebycheff	C4:151
110	Quantum Mechanical Integrals of Slater-Type Orbitals	C5:389 C5:393
111	Molecular-Orbital Calculation of Molecular Interactions	C5:390
132	Quantum Mechanical Integrals Over all Slater-Type Integrals	C5:551
184	Erlang Probability for Curve Fitting	C6:386
191	Hypergeometric	C6:388 C7:244 C17:589
192	Confluent Hypergeometric	C6:388 C7:244
227	Chebyshev Polynomial Coefficients	C7:295
282	Derivatives of e^x/x , $\cos(x)/x$ and $\sin(x)/x$	C9:272 C13:53
292	Regular Coulomb Wave Functions	C9:793 C12:278 C12:280 C13:573
300	Coulomb Wave Functions	C10:244 C12:279 C12:692 C16:308
327	Dilogarithm	C11:270
332	Jacobi Polynomials	C11:436 C13:449 C18:116
352	Characteristic Values and Associated Solutions of Mathieu's Differential Equation	C12:399 C13:750 C15:1074
388	Rademacher Function	C13:510
389	Binary Ordered Walsh Functions	C13:511

390	Sequency Ordered Walsh Functions	C13:511
490	The Dilogarithm Function of a Real Argument	C18:200 T2:112
537	Characteristic Values of Mathieu's Differential Equations	T5:112

S23

234	Poisson-Charlier Polynomials	C7:420 C8:105
-----	------------------------------	----------------------

Z : All Others

45	INTEREST	C4:178 C6:520
112	Position of Point Relative to Polygon	C5:434 C5:606
117	Magic Square (Even Order)	C5:435 C5:440 C6:39 C6:105
118	Magic Square (Odd Order)	C5:436 C5:440 C5:606 C6:39 C6:105
136	Enlargement of a Group	C5:555
148	Term of Magic Square	C5:605 C6:168 C6:168
199	Conversions Between Calendar Date and Julian Day Number	C6:444 C7:661
240	Coordinates On An Ellipsoid	C7:546
246	Graycode	C7:701 C8:382 T1:285 T11:441
252	Vector Coupling or Clebsch-Gordan Coefficients	C8:217
260	6-J Symbols	C8:492
261	9-J Symbols	C8:492
355	An Algorithm for Generating Ising Configuration	C12:562
364	Coloring Polygonal Regions	C12:685
391	Unitary Symmetric Polynomials	C13:512 C15:49
398	Tableless Date Conversion	C13:621 C15:918
428	Hu-Tucker Minimum Redundancy Alphabetic Coding Method	C15:360 C16:490
444	An Algorithm for Extracting Phrases in a Space-Optimal Fashion	C16:183
445	Binary Pattern Reconstruction from Projections	C16:185 C16:186
455	Analysis of Skew Representations of the Symmetric Group	C16:571
479	A Minimal Spanning Tree Clustering Method	C17:321 C18:119 T2:110
499	An Efficient Scanning Technique	T2:82
523	CONVEX: A New Convex Hull Algorithm for Planar Sets	T3:411
528	Framework for a Portable Library	T4:177 T5:524
532	Software for Roundoff Analysis	T4:388
536	An Efficient One-Way Enciphering Algorithm	T5:108
550	Solid Polyhedron Measures	T6:121
561	Fortran Implementation of Heap Programs for Efficient Table Maintenance	T6:444
564	A Test Problem Generator for Discrete Linear L_1 Approximation Problems	T6:615

568	PDS – A Portable Directory System	X3:162
588	Fast Hankel Transforms Using Related and Lagged Convolutions	T8:369
594	Software for Relative Error Analysis	T9:125
605	PBASIC – A Verifier Program for ANSI Minimal Basic	T9:391
606	NITPACK – An Interactive Tree Package	T9:418
607	Text Exchange System: A Transportable System for Management and Exchange of Programs and Other Text	T9:427
620	References and Keywords for <i>Collected Algorithms from ACM</i>	T10:359 T11:305 T16:401
622	A Simple Macroprocessor	T10:410

Appendix A

Availability of Data, Tools and Algorithm Sources

In addition to the Fortran code described in Appendix B there is a perl script for transforming the original database files into a number of more useful formats. Currently the perl script will generate

1. a `BIBTEX` database entry for each algorithm,
2. a cumulative index based on the `SHARE` classification like the one in [2],
3. a cumulative index based on the `GAMS` classification like the one in [3].

The algorithm databases available are

1. The `CALGO` algorithms published in *Communications of the ACM* from 1960–1975 and in *ACM Transactions on Mathematical Software* from 1975–,
2. The Applied Statistics algorithms published in *Applied Statistics* 1968–.

The databases and software are available via electronic mail or anonymous ftp from *unix.hensa.ac.uk*. The files are

- `acm.dbase` – the `CALGO` algorithms database,
- `acm.bib` – `BIBTEX` database of the `CALGO` algorithms,
- `as.dbase` – the Applied Statistics algorithms database,
- `as.bib` – `BIBTEX` database of the Applied Statistics algorithms,
- `bibeg.f`, `lib.f`, `shared.f` – Fortran 77 codes for operating on the database files. These codes are described in Appendix B,
- `bibop.sh` – a shar file containing the perl script, data files and man page as described above.

To obtain these files by electronic mail send mail of the form

```
send misc/netlib/bib/file
```

to `archive@unix.hensa.ac.uk` where `file` is replaced by the name of the file you require.

To obtain files via anonymous ftp, connect to `unix.hensa.ac.uk` (129.12.21.7) – the files are in the directory `misc/netlib/bib`. Compressed PostScript versions of [2] and [3] are also available for ftp in `misc/ukc.reports/reports/64` and `misc/ukc.reports/reports/71` respectively.

Please send bug reports, extensions to the perl script or further algorithm databases to `trh@ukc.ac.uk`.

Availability of algorithms

The sources to all algorithms published in TOMS and a number of those published in the Communications to the ACM are available via both e-mail and ftp.

To obtain copies via e-mail send a message of the form

```
send number from toms
```

where number is the number of the algorithm you require, e.g., to obtain algorithm 495 the message would be

```
send 495 from toms
```

to `netlib@unix.hensa.ac.uk` (UK/Europe) or `netlib@research.att.com` (US).

Using anonymous ftp connect to `unix.hensa.ac.uk` (129.12.21.7) from the UK and Europe or `research.att.com` (192.20.255.2) from the US, log in as anonymous and use your e-mail address as a password. To access the TOMS algorithms

```
cd netlib/toms
```

The algorithms currently available are

380, 386, 400, 403, 404, 406 – 408, 410, 413, 414, 419,
420, 432, 433, 458, 473 – 476, 478, 479, 483 – 485, 487,
488, 490, 493 –

Appendix B

A Remark on ACM TOMS Algorithm 620

We report on an enhanced version of the database originally reported in [6]. In this new version we have included all the information necessary to generate full bibliographic references. Extra information includes the author's name (including any accents), the page range of the original reference (rather than just the starting page), the month and year of publication and an abbreviated journal name. The programming language used to code the algorithm is also given. Any mathematical notation used within the algorithm title and accents in the author's name have been defined using $\text{T}_{\text{E}}\text{X}$ [4]. Following the practice used with $\text{B}_{\text{I}}\text{T}_{\text{E}}\text{X}$ [5], all letters within the title which need to remain capitalised in a printed version of the reference (e.g., Fortran, Bessel) are enclosed in braces.

The keywords and SHARE classification associated with each algorithm have been included with the main entry information rather than in a separate list as in [6]. Finally we have included references to all published remarks for each algorithm. These are in a compressed form which provides type (Remark or Certification), journal in which it appeared, volume, number, month and year of publication, page range and author.

The entry for each algorithm consists of either four or five records depending on whether there have been any published remarks. Each line in the file is restricted to 80 characters; records longer than this are continued on successive lines using a + in the first character position to denote that the line is a continuation line. Only the first record begins in character position one.

The first record gives details of the primary reference. The second and third are the author's name and title of the algorithm respectively. The keywords make up the fourth record. The first four records are always present. The final record provides details of remarks; individual fields within each remark reference are separated by commas and a semicolon is used to terminate each reference. Multiple remark references are treated as a single record.

As an example, the following entry is for algorithm 487

```
487   cacm  703  704 17 12  December 1974 s14   F
      J. Pomeranz;
      Exact Cumulative Distribution of the {K}olmogorov-{S}mirnov Statistic for
+ Small Samples
      goodness-of-fit testing;k-s statistic;k-s test;Kolmogorov-Smirnov test;
      R,toms,111,2,1,March,1976,J. Pomeranz;
+R,toms,285--294,3,3,September,1977,R. Kallman;
```

The first line should be interpreted as 'ACM CALGO Algorithm 487 appeared in Commun. ACM, Volume 17, Number 12, December 1974, pages 703–704'. The algorithm was implemented in Fortran and the modified SHARE classification is S14 (a sub-classification of the Special Functions).

The title spans two lines and contains two letters which must remain in upper case. The second remark is interpreted as being a Remark which appeared in ACM TOMS, Volume 3, Number 3 (second of the threes) in September 1977, pages 285–294. The author was R. Kallman.

We have provided Fortran routines which read in a reference in this compressed form and split the information up into a number of variables stored in a pair of common blocks. A template showing how to use these routines is given in Figure B.1. The two common blocks CREFNO and CREFST,

```

*
*  TEMPLATE FOR USE OF GETREF
*
*      LOGICAL GETREF
*
*  Insert COMMON block definitions here
*
*  Set up i/o channels and open data file
*  (This routine contains a possibly machine dependent
*  OPEN statement)
*      CALL SETUP
*
*  Set up output file -- application dependent routine
*      CALL OUTFIL
*
*  Initialize input buffer for references
*  a call to initrfr must precede calls to getref
*      CALL INITRF
*
*  Process all references
*  10 IF (GETREF()) THEN
*      process current reference
*      GO TO 10
*  END IF
*
*

```

Figure B.1: Template code for processing references

holding numerical and character data respectively, are defined by

```

INTEGER NUMBER, PAGEND, PAGEST, VOLUME, YEAR
COMMON /CREFNO/VOLUME, NUMBER, YEAR, PAGEST, PAGEND

INTEGER AUTLEN, TITLEN, KEYLEN, OTHLEN
PARAMETER (AUTLEN=80, TITLEN=160, KEYLEN=400
+          , OTHLEN=300)
CHARACTER AUTHOR(AUTLEN), KEYWDS(KEYLEN),
+          OTHERS(OTHLEN), TITLE(TITLEN)
CHARACTER ALABEL*(6), JOURNL*(4), MONTH*(9),
+          LANG*(3), SHARE*(3)

```

```
COMMON /CREFST/ALABEL, JOURNAL, MONTH, LANG, SHARE, AUTHOR,  
+      TITLE, KEYWDS, OTHERS
```

where

- JOURNAL contains the journal in which the algorithm was published (possible values are cacm, toms or topl),
- VOLUME, NUMBER, MONTH and YEAR store the volume, number, month and year of publication of the main reference,
- PAGEST and PAGEND give the page range of the main reference,
- the author and title are stored in the arrays AUTHOR and TITLE,
- the algorithm number (in two instances this contains a letter), implementation language (F = Fortran, A60 = Algol 60, PLI = PL1, R = Ratfor, N = None), and the Share index are placed in ALABEL, LANG and SHARE respectively;
- KEYWDS is an array containing the list of keywords separated by semicolons,
- the array OTHERS stores associated Remarks and Certifications. Each remark is separated by a semicolon and contains, as a list separated by commas
 - type of remark (R = Remark, C = Certification),
 - journal of publication (cacm or toms)
 - page range – either a pair of number separated by -- or a single integer for a one page remark,
 - the volume, number, month and year of the publication,
 - the author.

Two example programs are included which use these routines to generate a BIB_TE_X database and a cumulative index sorted by the SHARE index.

Bibliography

- [1] HOPKINS, T., AND MORSE, D. Remark on algorithm 620. *ACM Trans. Math. Softw.* 16, 4 (December 1990), 401–403.
- [2] HOPKINS, T., AND MORSE, D. Cumulative index to the ACM algorithms. Tech. Rep. 64 (Revised), Computing Laboratory, University of Kent, Canterbury, UK, Oct. 1992.
- [3] HOPKINS, T., AND MORSE, D. Cumulative index to the Applied Statistics algorithms. Tech. Rep. 71 (Revised), Computing Laboratory, University of Kent, Canterbury, UK, Oct. 1992.
- [4] KNUTH, D. E. *The TeXbook*. Addison-Wesley, Reading, Massachusetts, 1984.
- [5] LAMPORT, L. *LaTeX User's Guide & Reference Manual*. Addison-Wesley, Reading, Massachusetts, 1986.
- [6] RICE, J. R., AND HANSON, R. J. References and keywords for Collected Algorithms from ACM. *ACM Trans. Math. Softw.* 10, 4 (December 1984), 359–360.