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NUMERICAL EVALUATION OF SPECIAL FUNCTIONS

D. W. LOZIER AND F. W. J. OLVER

ABSTRACT. This document is an excerpt from the current hypertext version of an article that appeared in Walter Gautschi (ed.), *Mathematics of Computation 1943–1993: A Half-Century of Computational Mathematics*, Proceedings of Symposia in Applied Mathematics 48, American Mathematical Society, Providence, RI 02940, 1994. The symposium was held at the University of British Columbia August 9–13, 1993, in honor of the fiftieth anniversary of the journal *Mathematics of Computation*.

The original abstract follows.

Higher transcendental functions continue to play varied and important roles in investigations by engineers, mathematicians, scientists and statisticians. The purpose of this paper is to assist in locating useful approximations and software for the numerical generation of these functions, and to offer some suggestions for future developments in this field.

3.1. Software Packages. In this paper *software package* will mean a set of subroutines, or just a single subroutine, that addresses a subfield of numerical mathematics. There are three important series of software packages that include special functions. These packages are research contributions written in a variety of programming languages.

3.1.1. ♣ *ACM Algorithms.* These were published in the *Communications of the ACM*, Volumes 3–18 (1960–75) and since then in the *ACM Transactions on Mathematical Software* (*TOMS*). The transition between the two journals took place with Algorithm 493 in Volume 1, Number 2 of *TOMS*. Algol was required originally but Fortran and other languages were allowed after it became clear that this condition was too restrictive. A recent statement of the ACM Algorithms Policy appears in [**Kro91**]. The policy requires ACM Algorithms to be self-contained, adequately documented through comments in the code, and reasonably portable from one machine to another. A test program with sample output is also required. The policy provides for addenda to previously published algorithms. All ACM Algorithms that

[1] /nesf/Sect0/Sect0.html
[2] /nesf/Sect3/Sect3.html
[3] /nesf/Sect3/Sect3.html
[4] /nesf/Sect3-2/Sect3-2.html
[5] ftp://gams.nist.gov/pub/lozier/nesf/Paper.ps.Z
[6] ftp://gams.nist.gov/pub/lozier/nesf/Sect3-1.ps.Z

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appear in *TOMS* are refereed. The ACM Algorithms Policy has been in effect, with little change, since 1975.

A compendium of all ACM Algorithms is maintained in the 4-volume publication [**ACM**], a useful feature of which is that all addenda to an algorithm are printed together with the algorithm. This makes it unnecessary to gather the information from different journal issues. A quarterly looseleaf service keeps [**ACM**] up-to-date. The software itself is available on tape or diskette from the ACM Algorithms Distribution Service. Order forms are printed in each issue of *TOMS*. Alternatively, unofficial and possibly temporary electronic dissemination is being made available by Netlib[7] [**DG87**].

For indexing purposes, each ACM Algorithm is assigned a symbol from a modification of the SHARE classification system; cf. [**ACM**] or [**ACM64**]. Cumulative indexes by SHARE classification for 1960–1980, 1981–1986 and 1987–1988 appear in [**ACM**]. Algorithm 620 [**Ham85,HM90b,RH84**] provides a data base and Fortran program for preparing a cumulative index by SHARE classification. This data base is updated periodically by the ACM Algorithms Distribution Service and Netlib.

3.1.2. ♣ *AS Algorithms.* A section for statistical subroutines in *Applied Statistics* was established in 1968 to "encourage the development of a published literature on statistical computing" as the specialized needs of statistical computing were "only partly met" by the algorithm sections of other journals [**AS68**]. The current version of detailed instructions and other information for authors of AS Algorithms, first published in 1968, can be found in [**RWGH87**]. All submissions adhere to a standard format and are refereed. A test program is required for the referee's use. Addenda to previously published algorithms are accepted and are subjected to the same refereeing process as original algorithms. An index appears at the end of every volume. A cumulative index of the first 251 AS Algorithms (1968–1989, with addenda) appears in [**HM90a**], organized according to the GAMS scheme [**BHK91**]. Corrected and improved versions of selected AS Algorithms appear in [**GH85**]. Instructions for obtaining AS Algorithms on computer diskette can be found in issues of *Applied Statistics* starting in 1993.

3.1.3. ♣ *CPC Programs.* The journal *Computer Physics Communications* was begun in 1969 to "facilitate the exchange of physics programs and of relevant information about the use of computers in the physics community". It publishes descriptions of CPC Programs and, in addition, general papers on the computational aspects of physics and physical chemistry. Programs and their descriptions are refereed.

Program descriptions consist of a Program Summary (a concise description in a standard format with keywords) and a Long Write-Up (a detailed description of the underlying physics and algorithms). A test program is required for each CPC Program, and each CPC Program is required to be well documented and as portable and self-contained as possible. An index of CPC Programs is printed at the end of every volume. Two cumulative indexes without Program Summaries [**CPC87,CPC90**] and one with Program Summaries [**CPC84**] exist. A more attractive alternative is the up-to-date electronic index[8] (with Program Summaries).

[7] To get started with Netlib, send the message "help" to `netlib@ornl.gov`.

[8] To get started with the electronic index, send the message "get cpc intro cpcindex" to

All these indexes are organized according to a physics-oriented classification scheme.

CPC Programs can be ordered individually or by subscription service. Ordering instructions and an order form are printed in the back of every issue of *Computer Physics Communications.*

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