

ALGORITHM 93  
 GENERAL ORDER ARITHMETIC  
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**procedure** arithmetic (a, b, c, op);

**integer** a, b, c, op;

**comment** This procedure will perform different order arithmetic operations with  $b$  and  $c$ , putting the result in  $a$ . The order of the operation is given by  $op$ . For  $op = 1$  addition is performed. For  $op = 2$  multiplication, repeated addition, is done. Beyond these the operations are non-commutative. For  $op = 3$  exponentiation, repeated multiplication, is done, raising  $b$  to the power  $c$ . Beyond these the question of grouping is important. The innermost implied parentheses are at the right. The hyper-exponent is always  $c$ . For  $op = 4$  tetration, repeated exponentiation, is done. For  $op = 5, 6, 7$ , etc., the procedure performs pentation, hexation, heptation, etc., respectively.

The routine was originally programmed in FORTRAN for the Control Data 160 desk-size computer. The original program was limited to tetration because subroutine recursiveness in Control Data 160 FORTRAN has been held down to four levels in the interests of economy.

The input parameter,  $b$ ,  $c$ , and  $op$ , must be positive integers, not zero;

**begin own integer** d, e, f, drop;

**if** op = 1 **then**

**begin** a := b + c; go to 1

**end if** op = 2 **then** d := 0;

**else** d := 1; e := c; drop := op - 1;

**for** f := 1 **step** 1 **until** e **do**

**begin** arithmetic (a, b, d, drop);

      d := a

**end;**

1: **end** arithmetic

CERTIFICATION OF ALGORITHM 93  
 GENERAL ORDER ARITHMETIC [Millard H. Per-  
 stein, *Comm. ACM* (June 1962)]

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Algorithm 93 was programmed for the IBM 1620, using "FORTRAN-recursion" (i.e., generous use of the copy rule). The program ran without any modifications and was tested through tetration. Further levels were available, but were too time-consuming to reach.